Appendix 1: Base Case Assumptions

1 Introduction 4

2 Documentation for Base Case Parameter Values 9
2.1 AMInspector 9
2.1.1 probPassAM 9
2.2 birthVisitor 9
2.2.1 probBirth 9
2.2.2 probTrans 10
2.2.3 beginCalving 10
2.2.4 endCalving 11
2.3 bloodInfector 11
2.3.1 numCowsReceiving 11
2.3.2 probInfection 11
2.3.3 consumption 12
2.3.4 susceptibility 12
2.4 deathVisitor 12
2.4.1 probDeath 12
2.5 feeder 13
2.5.1 probFeedOK 13
2.6 feedProducer 15
2.6.1 probFeedType 15
2.6.2 probMisLabel 15
2.6.3 probContaminate 15
2.6.4 fracContaminate 16
2.7 feedTransporter 16
2.7.1 probDestination 16
2.8 FoodInspector 16
2.8.1 probPassFood 16
2.9 genesisVisitor 17
2.9.1 initSize 17
2.10 materializer 20
2.10.1 organDistribution 20
2.10.2 totalInfectivity 21
2.11 MBMTransporter 21
2.11.1 probDestination 21
2.12 PMInspector 22
2.12.1 probPassPM 22
2.13 proteinInfector 22
2.13.1 numCowsReceiving 22
2.13.2 probInfection 23
2.13.3 consumption 23
2.13.4 susceptibility 23
2.14 randomInfector 24
2.15 rateSlaughter 24
2.16 renderer 24
2.16.1 renderFactor 24
2.16.2 probContamination 25
2.16.3 probType 25
2.16.4 probMisLabel 26
2.16.5 fracContaminate 28
2.17 sickBovine 28
2.17.1 clinicalDate 28

2.17.2 clinicalDuration.......... 29
2.17.3 maternalContageousPoint 30
2.18 splitter 30
2.18.1 fracAerosol.......... 30
2.18.2 probMS_AMR_SCRRemove.......... 30
2.18.3 fracSCInMuscle, fracSCInAMRMeat, and fracSCInBone 32
2.18.4 fracDRGInMuscle, fracDRGInAMRMeat, and fracDRGInBone.......... 34
2.19 Stunner.......... 35
2.19.1 probDrip.......... 35
2.19.2 fracDrip.......... 35
2.19.3 probType.......... 36
2.19.4 probOK 36
2.19.5 emboli 37
2.20 Other Parameters.......... 38
2.20.1 farmDeathDisp.......... 38

3 Base Case Parameter Values.......... 38
3.1 AMInspector 38
3.1.1 probPassAM.......... 38
3.2 birthVisitor.......... 38
3.2.1 probBirth.......... 38
3.2.2 probTrans 39
3.2.3 beginCalving.......... 39
3.2.4 endCalving 39
3.3 bloodInfector.......... 39
3.3.1 numCowsRecieving 39
3.3.2 probInfection.......... 39
3.3.3 consumption.......... 39
3.3.4 Susceptibility.......... 44
3.4 deathVisitor.......... 45
3.4.1 probDeath.......... 45
3.5 feeder 46
3.5.1 probFeedOK.......... 46
3.6 feedProducer 46
3.6.1 probFeedType 46
3.6.2 probMislabel 46
3.6.3 probContaminate.......... 46
3.6.4 fracContaminate.......... 47
3.7 feedtransporter 47
3.7.1 probDestination.......... 47
3.8 foodInspector 47
3.8.1 probPassFood.......... 47
3.9 genesisvisitor.......... 48
3.9.1 initSize 48
3.10 materializer 63
3.10.1 organDistribution 63
3.10.2 totalInfectivity.......... 64
3.11 MBMtransporter 65
3.11.1 probDestination.......... 65
2.12 PMInspector.......... 66
3.12.1 ProbPassPM 66
3.13 proteinInfector.......... 66
3.13.1 probInfection.......... 66
3.13.2 numCowsReceiving 66
3.13.3 consumption.......... 67
3.13.4 susceptibility 71

3.14 randomInfector 71
3.15 rateSlaughter 71
3.15.1 rateSlaughter 71
3.16 renderer 72
3.16.1 renderFactor 72
3.16.2 probContamination 73
3.16.3 probType 73
3.16.4 probMislabel 73
3.16.5 fracContaminate 73
3.17 sickBovine 73
3.17.1 clinicalDate 73
3.17.2 clinicalDuration 76
3.17.3 maternalContagiousPoint 76
3.18 splitter 77
3.18.1 fracAerosol 77
3.18.2 probMS_AMR_SCRemove 77
3.18.3 fracSCInMuscle, fracSCInAMRMeat, fracSCInBone 77
3.18.4 fracDRGInMuscle, fracDRGInAMRMeat, fracDRGInBone 79
3.19 Stunner 80
3.19.1 probDrip 80
3.19.2 fracDrip 80
3.19.3 probType 80
3.19.4 probOK 80
3.19.5 emboli 81
3.20 Other Parameters 82
3.20.1 farmDeathDisp 82

1 Introduction

This appendix details the values assigned to the parameters for the base case scenario described in this report (Section 3) and summarizes the key documentation supporting these assumptions (Section 2). The parameters have been organized into a series of tables, and the tables are each associated with a parameter group. The remainder of this introduction lists each of the parameter groups in alphabetical order, along with brief descriptions of each parameter, some of which are tables, and some of which are numerical values.

This section lists all the top level elements and the parameters that they contain.

Parameter Group Parameter	Comment
<AMInspector>	
<probPassAM>	Specifies the probability a bovine will pass ante mortem inspection. The probability depends on the animal's age and whether it displays clinical BSE signs.
<birthVisitor>	
<probBirth>	Specifies probability that a cow that can calf will give birth in any given month
<probTrans>	Specifies he probability that a newborn calf becomes infected if its mother is infected with BSE and if the ratio of the duration since infection to the total incubation time exceeds <maternalContagiousPoint> (see parameter group sickBovine).
<beginCalving>	Specifies age in months when a cow can begin calving
<endCalving>	Specifies maximum age at which a cow can calve
<bloodInfector>	
<numCowsReceiving>	Specifies number of bovines among which blood meal from a single slaughtered animal is divided
<probInfection>	Specifies a point-wise description of the BSE dose-response relationship between susceptibility-adjusted ID_{50}s ingested and the probability of BSE infection. The number of susceptibility-adjusted ID_{50}s ingested equals the product of the animal's age-specific susceptibility value and the number of unadjusted ID_{50}s ingested.
<consumption>	Specifies the relative blood meal consumption weight for each age / gender / bovine type combination. These relative weights are proportional to the probability that an animal will ingest

Parameter Group **Parameter**	**Comment**
	infectivity in blood meal.
<susceptibility>	Specifies the relative susceptibility of a bovine to becoming BSE infected following ingestion of contaminated blood meal as a function of age. See <probInfection> above.
<DeathVisitor>	
<probDeath>	Specifies the monthly probability of death by natural causes (*i.e.*, excluding slaughter and death due to BSE)
<feeder>	
<probFeedOK>	Specifies the probability that prohibited feed sent to the farm will <u>not</u> be fed to bovines
<feedProducer>	
<probFeedType>	For <u>mixed feed producers only</u>, this parameter specifies the proportion of MBM that is used to produce prohibited feed and non-prohibited feed. These probabilities depend on whether the MBM is prohibited or non-prohibited. Note – The simulation assumes that prohibited feed producers produce only prohibited feed, and that non-prohibited feed producers produce only non-prohibited feed.
<probMisLabel>	Specifies the probability a producer will mislabel prohibited feed that it produces as non-prohibited. The probability depends on the food producer type (prohibited, non-prohibited, or mixed). Note that ordinarily, this probability should be 1.0 for non-prohibited feed producers because their output is exclusively labeled non-prohibited feed. Therefore, any prohibited feed they produce is by definition mislabeled.
<probContaminate>	Specifies the probability that a batch of prohibited feed will contaminate a batch of non-prohibited feed. The probability depends on the producer type (prohibited, non-prohibited, or mixed).
<fracContaminate>	Specifies the fraction of infectivity in a batch of prohibited feed that ends up in non-prohibited feed if contamination occurs.
<feedTransporter>	
<probDestination>	Specifies the probability that feed will ultimately be sent to a farm or “OUT” (*i.e.*, to a use that poses no threat of exposing cattle). The probability depends on the type of feed producer (prohibited, non-prohibited, or mixed), and the type of feed (prohibited or non-prohibited).

Parameter Group Parameter	Comment
<foodInspector>	
<probPassFood>	Specifies the probability that an organ will not be rejected by the food inspector for the purpose of being sold for human consumption. This probability depends on the organ type.
<genesisVisitor>	
<initSize>	Specifies the number of animals in the herd at the beginning of the simulation for each combination of bovine type, gender, and age.
<materializer>	
<organDistribution>	Specifies the proportion of a bovine's BSE infectivity in each organ. The proportion depends on the organ and the number of months since infection.
<totalInfectivity>	Specifies the total number of ID_{50}s in an animal as a function of time since infection.
<MBMTransporter>	
<probDestination>	Specifies the probability that MBM is sent to prohibited feed producers, mixed feed producers, non-prohibited feed producers, or "OUT" (*i.e.*, to a use that poses no threat of exposing cattle). The probabilities depend on the type of MBM producer (prohibited, non-prohibited, or mixed) and the type of MBM (prohibited or non-prohibited).
<PMInspector>	
<probPassPM>	Specifies the probability that the PM inspector will accept an organ. The probability depends on the age of the animal and the presence of emboli.
<proteinInfector>	
<numCowsReceiving>	Specifies number of bovines among which protein from a single slaughtered animal is divided
<probInfection>	Specifies a point-wise description of the BSE dose-response relationship between susceptibility-adjusted ID_{50}s ingested and the probability of BSE infection. The number of susceptibility-adjusted ID_{50}s ingested equals the product of the animal's age-specific susceptibility value and the number of unadjusted ID_{50}s ingested.
<consumption>	Specifies the a relative animal protein consumption weight for each age / gender / bovine type combination. These relative weights are proportional to the probability that an animal will ingest infectivity in feed supplemented with animal protein.

Parameter Group Parameter	Comment
<susceptibility>	Specifies the relative susceptibility of a bovine to becoming BSE infected following ingestion of contaminated animal protein as a function of age. See <probInfection> above.
<randomInfector>	Same as proteinInfector, but pertains to animal protein from sources other than cattle slaughtered in the U.S.
<renderer>	
<renderFactor>	Specifies the probability distribution for render reduction factors in the U.S.
<probContaminate>	Specifies probability that a batch of prohibited MBM produced by a MIXED MBM producer will contaminate a batch of non-prohibited feed.
<probType>	Specifies the probability that bovine material sent to rendering will be sent to a prohibited, mixed, or non-prohibited renderer.
<probMisLabel>	Specifies the probability a renderer will mislabel prohibited MBM as non-prohibited. The probability depends on the renderer type (prohibited, non-prohibited, or mixed). Note that ordinarily, this probability should be 1.0 for non-prohibited renderers because their output is exclusively labeled non-prohibited MBM. Therefore, any prohibited MBM they produce is by definition mislabeled.
<fracContaminate>	Specifies the fraction of infectivity in a batch of prohibited MBM that ends up in non-prohibited MBM if contamination occurs.
<sickBovine>	
<clinicalDate>	Specifies a probability distribution for the duration between infection and the manifestation of clinical BSE signs.
<clinicalDuration>	Specifies a probability distribution for the duration between the manifestation of clinical
<splitter>	
<fracAerosol>	Specifies the proportion of BSE in the spinal cord that is aerosoloized and ends up on the carcass (in muscle meat) during splitting.
<probMS_AMR_SCRRemove>	Specifies the proportion of animals with each possible combination of splitter outcomes. These outcomes consist of all eight possible combinations of: mis-split (yes/no), use of AMR (yes/no), and removal of spinal cord (yes/no). The probability depends on age.
<fracSCInMuscle>	Specifies the fraction of infectivity in spinal cord that ends up in muscle meat following splitting. The fraction depends on age and the splitter outcome (see <probMS_AMR_SCRemove>).

Parameter Group Parameter	Comment
<fracSCInAMRMeat>	Specifies the fraction of infectivity in spinal cord that ends up in AMR product following splitting. The fraction depends on age and the splitter outcome (see <probMS_AMR_SCRemove>).
<fracSCInBone>	Specifies the fraction of infectivity in spinal cord that ends up in bone cuts of meat following splitting. The fraction depends on age and the splitter outcome (see <probMS_AMR_SCRemove>).
<fracDRGInMuscle>	Specifies the fraction of infectivity in DRG that ends up in muscle meat following splitting. The fraction depends on age and the splitter outcome (see <probMS_AMR_SCRemove>).
<fracDRGInAMRMeat>	Specifies the fraction of infectivity in DRG that ends up in AMR product following splitting. The fraction depends on age and the splitter outcome (see <probMS_AMR_SCRemove>).
<fracDRGInBone>	Specifies the fraction of infectivity in DRG that ends up in bone cuts of meat following splitting. The fraction depends on age and the splitter outcome (see <probMS_AMR_SCRemove>).
<stunner>	
<ProbDrip>	Specifies the probability that brain will drip from stunner hole, contaminating blood collected for potential use as animal blood meal. This probability depends on the type of stunner technology used.
<fracDrip>	Specifies the fraction of infectivity in brain that ends up in blood if contamination occurs.
<probType>	Specifies the proportion of cattle stunned using each type of stunner technology.
<probOK>	Specifies the probability that the there is <u>no</u> stunner malfunction. The probability depends on the type of stunner used.
<emboli>	Specifies two sets of quantities. The first set consists of a single quantity that is the probability that there will be emboli in an organ. This probability depends on the organ, type of stunner used, and whether the stunner malfunctions. The second set of quantities are the lower and upper bounds for a uniform distribution quantifying the fraction of infectivity in brain that ends up in an organ if there are any emboli in that organ.
Parameters not belonging to any top level element	
<rateSlaughter>	Specifies the proportion of cattle slaughtered each month. Values depend on cattle type, gender, and age.
<farmDeathDisp>	Specifies the probability that an animal that dies of natural causes (*i.e.*, not BSE and not slaughter) will be disposed of on the farm (instead of being sent to rendering).

2 Documentation for Base Case Parameter Values

2.1 AMInspector

2.1.1 probPassAM

This parameter quantifies the probability that an animal will pass AM inspection. This probability depends on the animal's age and on whether it has clinical signs of BSE. Animals that have no signs are divided into three groups: calves (younger than 12 months of age), steers and heifers (between the ages of 12 and 24 months), and cows, bulls, and stags (older than 24 months of age). Information on the AM condemnation rate is provided by the following reference:

- USDA, FSIS, Animal Reporting System (ADRS) livestock slaughtered in USDA year 1998.

For animals with clinical BSE signs, our estimate for the condemnation rate is based on the following references:

- Dagmar Heim, personal communication.
- USDA, APHIS: BSE Surveillance
- Heim, D., Wilesmith, J. W.,(2000) Surveillance of BSE, Archives of Virology – Supplementum16, 127-33
- Miller, L. D., Davis, A. J., Jenny, A. L., Fekadu, M., Whitfield, S. G (1993) Surveillance for lesions of bovine spongiform encephalopathy in U.S. cattle, Developments in Biological Standardization 80, 119-121

2.2 birthVisitor

2.2.1 probBirth

This numerical parameter quantifies the probability that a cow will give birth in any given month. Our estimate is based on the assumption that a cow gives birth once each year.

2.2.2 probTrans

This parameter represents the probability that a newborn calf becomes infected if its mother is infected with BSE and the mother has lived through at least a fixed fraction of her incubation period. That fraction is specified by the <maternalContagiousPoint > parameter in parameter element sickBovine. Our estimate for probTrans is based on the following references:

- Donnelly, CA; Ferguson, NM et al (1997). “ The epidemiology of BSE in cattle herds in Great Britain. 1 Epidemiological processes, demography of cattle and approaches to control by culling”. Philosophical Transactions of the Royal Society of London – Series B: Biological Sciences 352 (1355): 781-801
- Anderson, RM; Donnelly, et al. “Transmission dynamics and epidemiology of BSE in British cattle”. Nature 382 779-788
- Donnelly, CA; Ghani, AC et al (1997). “Analysis of the bovine spongiform encephalopathy maternal cohort study: Evidence of direct maternal transmission” Appl Statist 46:321-344
- Donnelly, CA. (1998) “Maternal transmission of BSE: interpretation of the data on the offspring of BSE-affected pedigree suckler cows” Veterinary Record. 142(21):579-80
- MAFF: Epidemiology of BSE

2.2.3 beginCalving

This parameter represents the youngest age (in months) at which a cow can give birth to a calf. Our estimate is based on the following references:

- Radostits, OM, Leslie, KE, Fetrow, J (1994)” Herd Food Animal Production Medicine”, Second Edition, WB Saunders Company
- USDA-National Agriculture Statistics Service- http://www.nass.usda.gov:81/ipedb/
- USDA-APHIS- National Animal Health Monitoring System http://www.aphis.usda.gov/vs/ceah/cahm/General.htm

2.2.4 endCalving

This parameter represents the oldest age (in months) at which a cow can give birth to a calf. Our estimate is based on the same references used to estimate beginCalving (see Section 2.2.3).

2.3 bloodInfector

2.3.1 numCowsReceiving

This parameter represents the number of bovines among which blood meal from a single slaughtered animal is divided. The estimate is based on the assumption that a single batch of blood meal is sent to one farm and that batch contains 4,000 pounds of blood. Dairy cattle consume an average of 3% of their body weight per day, or 30 pounds. A typical dairy ration consists of 5% blood meal, indicating that a single dairy animal will consume 1.5 pounds of blood meal per day. Hence, the 4,000 pounds of blood meal represents approximately 2,667 daily rations. Assuming that the supply is consumed within 30 days of its purchase, the 2,667 rations will be divided among approximately 88 animals. These assumptions are based in part on the following references

- Ensminger, ME; Oldfield, JE; Heinemann, WW (1990) "Feeds and Nutrition". The Ensminger Publishing Company, USA
- Conversations with representatives of the rendering industry

2.3.2 probInfection

This parameter represents the probability that an animal will become infected with BSE after consuming a specified number of susceptibility-adjusted ID_{50}s. The"susceptibility-adjusted" number of ID_{50}s equals the product of the number of ID_{50}s ingested and the animal's age-specific susceptibility. The function used in the base case assumes that the probability of infection equals one-half the number of susceptibility-adjusted ID_{50}s ingested when the number of adjusted ID_{50}s is no more than 2.0. For larger exposures, the base case assumes that the probability of infection is 100%.

2.3.3 consumption

This parameter represents the relative consumption of blood meal for each bovine type, gender, age combination. These relative weights are proportional to the probability that an animal will ingest infectivity in blood meal. These proportions are based on the daily feeding practices described by the following two references:

- Larry Satter, USDA-(personal communication)
- Jim Quigley, APC Company, Inc, personal communication

2.3.4 susceptibility

This parameter quantifies the relative susceptibility of a bovine to BSE infection *via* oral exposure. In particular, the probability of infection (see parameter probInfection above) depends on the product of the number of oral ID_{50}s consumed and the age-specific susceptibility parameter. We use the susceptibility function described by Koeijer et al. (in press) (see their Equation 7). For animals age 4 months and older, susceptibility (β(a)) is

$$\beta(a) = 0.1 + 1.8 \times e^{-2a},$$

where a is age in years. The complete citation for this reference is:

- Koeijer, A., Schreuder, B., Heesterbeek, H., Oberthur, R., Wilesmith, J., de Jong, M. "BSE Risk assessment by calculating the basic reproduction ratio for the infection among cattle". *In press.*

2.4 deathVisitor

2.4.1 probDeath

This parameter specifies the age-specific probability that cattle will die as a consequence of non-BSE related causes. The rates we used were inferred from annual natural death rates for beef and dairy animals. We assume that beef cattle have a natural death rate of 0.1% per month during their entire lives. For dairy cattle, we estimate that the natural death rate during the first year of life may be 5% to 10%. We assume that the death rate is 5% during months 0 and 1, and that it falls to 0.1% per month for ages 2 months to 20 months. After that time, the natural death rate increases slowly to 0.25% (3% per year).

- (Radostits et al., 1994)
- (USDA-NAHMS, 1996)
- (USDA-NAHMS, 1997)

2.5 feeder

2.5.1 probFeedOK

This parameter represents the probability that properly labeled prohibited feed is not fed to bovines on the farm. This probability depends on whether the farm also raises animals that consume prohibited feed. In particular, we assume that the probability that a "packet" of prohibited feed is administered to cattle equals the product: 1) the proportion of farms with animals consuming prohibited feed that also have cattle, and 2) the probability that such an operation incorrectly administers prohibited feed to cattle. We assume that animals consuming prohibited feed include hogs and pigs, egg-laying hens and pullets, broilers, and turkeys. Our computations ignore the fact that that farms have different numbers of animals. There are insufficient data to take this variation into account.

We use Bayes law to calculate the probability that dairy animals are present on a farm given the presence of animals that can consume prohibited feed, designated "*Prob(Dairy | Prohibited)*". In particular,

$$\text{Prob}\,(Dairy \mid Prohibited) = \frac{\text{Prob}\,(Prohibited \mid Dairy) \times \text{Prob}\,(Dairy)}{\text{Prob}\,(Prohibited)},$$

where Prob*(Prohibited | Dairy)* is the probability that a farm raises animals consuming prohibited feed given the presence of dairy cattle, Prob*(Dairy)* is the proportion of farms that raise dairy cows, and Prob*(Prohibited)* is the proportion of farms that raise animals consuming prohibited feed. Note that this computation is limited to dairy animals because we were unable to identify data to estimate Prob(*Prohibited | all cattle*) or Prob(*Prohibited | beef*).

We estimate the value of the quantity, Prob*(Prohibited | Dairy)* as the sum of Prob(*Chicken* | *Dairy*) and Prob(*Hogs* | *Dairy*). These two proportions are reported by U.S. Dairy 1996 (Section E, part 1b) to be 7.5% and 3.9%, respectively, yielding a sum of 11.4%. The value of Prob(*Dairy*) was calculated by dividing the total number of milk cow inventory farms (116,874) by the number of total farms (1,911,859), yielding 6.1%. The value of Prob(*Prohibited*) was calculated by dividing the total number of hog/pig farms (109,754), egg laying hens/pullets farms (69,761), broiler chicken farms (23,937) and turkey farms (6,031) by the total number of farms (1,911,859), yielding 11.0%. Farm count values were reported by USDA National Agricultural Statistics Service Census (1997). Plugging these values into the preceding equation yields Prob(*Dairy* | *Prohibited*) = 6.4%.

Finally, we assume that beef operations are distinct from dairy operations and that Prob(Beef | Prohibited) is equal to the value of Prob(Dairy | Prohibited) scaled by the number of beef operations compared to the number of dairy operations. As a result, we assume

$$\text{Prob}(AllCattle \mid \text{Pr}ohibited) = \text{Prob}(Dairy \mid \text{Pr}ohibited) * \left(1 + \frac{N_{Beef}}{N_{Dairy}}\right),$$

where Prob*(AllCattle | Prohibited)* is the probability of any cattle being raised on a farm if there are animals that consume prohibited feed, and N_{Beef} and N_{Dairy} are the number of beef operations and dairy operations in the U.S., respectively. Using the values from USDA National Agricultural Statistics Service Census (1997) of N_{Dairy} = 116,874 and N_{Beef} = 804,595 yields Prob*(AllCattle | Prohibited)* = 5.0%.

Finally, we assume that one-thirtieth of the prohibited feed sent to farms that raise both cattle and animals consuming prohibited feed is administered to cattle. As a result, the misfeeding rate is approximately 1.7% and the value of ProbFeedOK is 98.3%[1]

[1] Due to rounding error, the parameter ProbFeedOK actually used in the base case is 98.4%, corresponding to a misfeeding rate of 1.6%.

2.6 feedProducer

2.6.1 probFeedType

This parameter quantifies the probabilities that rendered material sent to a mixed feed producer will be used to produce either prohibited feed or non-prohibited feed in the absence of both mislabeling and contamination. The base case assumes that non-prohibited MBM is always used to produce non-prohibited feed because of the price premium it commands.

- David W. Harlan,Taylor Byproducts personal communication
- Dennis K. Mullane, Taylor Byproducts, personal communication
- Feed, Rendering Industries Launch Feed Certification Program. Published 3/19/01 (http:wwwmeatingplace.com mal)

2.6.2 probMisLabel

This parameter represents the probability that a prohibited or mixed feed producer will mislabel prohibited feed that it produces as non-prohibited. We estimate that mixed producers and prohibited producers mislabel 5% of their prohibited feed as non-prohibited. This value was estimated jointly with the probability that MBM producers mislabel their prohibited product. The basis for these estimates is described in the discussion of the <probMisLabel> parameter in the renderer parameter group.

2.6.3 probContaminate

This parameter represents the probability that a batch of prohibited feed will contaminate a batch of non-prohibited feed. We assume that this probability is zero for prohibited and non-prohibited producers. For mixed producers, our estimate is based on the degree to which producers comply with FDA regulations designed to prevent comingling of prohibited and non-prohibited feed material. References used to develop the base case assumptions included the following:

- FDA-BSE Enforcement activities-March 23, 2001
- Food and Drug Administration, Substances Prohibited From Use in Animal Food or Feed; Animal Proteins Prohibited in Ruminant Feed; Final Rule-21 CFR Part 589, 1997

2.6.4 fracContaminate

This parameter represents the fraction of ID_{50}s in a batch of prohibited feed that ends up in non-prohibited feed if contamination occurs. Our estimate for this parameter is based on the assumption that flushing and cleaning procedures in a mixed mill leaves 0.1% of the prohibited materials behind by volume. This estimate reflects two sets of personal communications:

- David W. Harlan, Taylor Byproducts personal communication
- Burt Pritchet, FDA, based on clean out procedures required for medicated feed (good manufacture guidelines and compliance policy guidelines)

2.7 feedTransporter

2.7.1 probDestination

This parameter represents the probability that feed will be sent to a farm with cattle or to some other destination at which there is no potential for cattle exposure. If feed is exported to other countries, we assume that domestic cattle cannot later be exposed to it. Furthermore, we assume that non-prohibited feed is more likely than non-prohibited feed to be diverted to non-livestock uses. In the case of blood meal, we assumed that only 15% will ultimately be sent to farms where cattle might become exposed. References used to develop these assumptions include the following:

- Faostat Agricultural data http://apps.fao.org/page/collections?subset=agriculture
- NASS-USDA http://www.usda.gov/nass/

2.8 FoodInspector

2.8.1 probPassFood

This parameter represents the probability that specific organs/tissues will be available for human consumption in the United States. Some variety meats (*e.g.,* eyes) are not likely to be available for human consumption in the U.S. Other variety meats are consumed in the U.S. only by members of specific groups. Finally, some variety meats are consumed by populations outside the U.S. Base case assumptions were developed in part from information provided by the following sources:

- Nathan Bauer, USDA-FSIS personal communication
- Robert Brewer, USDA-FSIS personal communication
- Variety Meats from USA: A Buyer's Guide-USA Meat Export Federation, 1995
- European Assumptions on: Biosafety and Risk Analysis for the use of Spray Dried Plasma and other blood derivatives in Animal Feed-APC Europe,Volume 1-Analysis, October 1999.

2.9 genesisVisitor

2.9.1 initSize

The initSize parameter is a table of values quantifying the number of animals in each age/gender/type category. The specific population values for each age/type/gender category were computed using spreadsheet software in an effort to develop assumptions that are both consistent with published statistics and that produce a population with a stable size (*i.e.*, the number of animals that are not slaughtered and do not die of other causes at age *i* equals the number of animals alive at age *i*+1). The text below describes the development of these values for dairy cattle and beef cattle. References used to develop the initial population size estimates included the following:

- USDA-APHIS- National Animal Health Monitoring System http://www.aphis.usda.gov/vs/ceah/cahm/Dairy_Cattle/dairy.htm, http://www.aphis.usda.gov/vs/ceah/cahm/Beef_Cow-Calf/beef.htm, and http://www.aphis.usda.gov/vs/ceah/cahm/Beef_Feedlot/bffeed.htm
- USDA -Cattle Final estimates 1994-1998 http://www.usda.mannlib.cornell.edu/reports/general/sb/b9530199.pdf
- USDA: ANIMAL DISPOSITION REPORTING SYSTEM ADRS) http://www.fsis.usda.gov/OPHS/adrsdata/1998adrs/adrsfy98.htm

Dairy Cattle

The Agricultural Statistics Board (Cattle Final Estimates 1994-1998, p. 4) (USDA-NASS, 1999) reported that in 1998 there were a total of 9.2 million dairy cows in the US. We assume that this figure refers to dairy females at least 24 months of age. Dairy Management Practices (1996, p. 30) (USDA-NAHMS, 1996) reported that the natural death rate among female dairy calves between birth and weaning (around age 2 months) is 10.8%. We therefore assume that the death rate during months 0 and 1 is 5.4% per month. Dairy Management Practices (p. 32) also reported that between the ages of 2 months and 24 months, the death rate for female dairy cattle is 2.4% per year, a value that corresponds to a monthly death rate of approximately 0.2%. Radostits et al. (1994) (Radostits et al., 1994) reported that after the age of 24 months, the natural annual death rate is 3.3% for female dairy cows, or approximately 0.3% per month. Radostits et al. (p. 160) have reported that the annual culling rate for cows is 20% to 35%. We assume that this rate increases from 18% among animals 21 months old to 50% among animals who are at least 84 months old. Given these slaughter rates and natural death rates, a birth rate of 290,000 female dairy cattle per month (3.5 million per year) is necessary to ensure that the number of female dairy cows (age ≥ 24 months) equals 9.2 million.

We assume that male dairy cattle have the same birth rate as female dairy cattle (290,000 per month). Radostits et al. (p. 185) estimated that the natural death rate during the first year of life may be 5% to 10%. We assume that the death rate is 5% during months 0 and 1, and that it falls to 0.1% per month for ages 2 months to 20 months. After that time, the natural death rate increases slowly to 0.25% (3% per year). Radostits et al. noted that male dairy calves constitute an inexpensive supply of veal animals and hence a large fraction of them are slaughtered before they reach the age of one year. In particular, they stated that the ratio of the number of dairy females to the number of dairy males above the age of one year may be as high as 35 (p. 144). Thereafter, unproductive males are culled. We assume that between the ages of 13 and 23 months, the monthly culling rate is 1.25%, and that this value increases steadily to 2.6% at later ages.

Beef Cattle

The number of steers slaughtered during calendar year 1998 was 19.8 million (USDA-ADRS). These animals are by definition at least 13 months of age. The natural death rate for male beef cattle during the first month of life is assumed to be 5% (Cow Calf Production, p. 13) (USDA-NAHMS, 1997). Radotstits et al. reported that after the first month of life, the annual death rate falls to around 1% (p. 400). Producing enough males to ensure that 19.8 million at least 13 months of age can be slaughtered each year requires a birth rate of 1.77 million per month (21.2 million per year).

There are far fewer beef bulls than steers. The Agricultural Statistics Board (p. 4) (USDA-NASS, 1999) reported that in 1998, there were approximately 2.3 million bulls (beef and dairy combined) over 500 pounds, which we assume corresponds to ages 7 months and greater. We assume that the natural death rate for beef bulls is the same as it is for dairy bulls. We also assume that these animals are not culled until they reach the age of 13 months, after which time, we assume that their culling rate is the same as the culling rate for dairy bulls. A birth rate of 30,000 males per month yields a total of 1.2 million beef bulls at least 13 months of age. The number of dairy bulls above the age of 13 months is 600,000, yielding a total of 1.8 million bulls above the age of 13 months, which is close to the value reported by the Agriculture Statistics Board of 2.3 million.

Totaling the birth rate for male beef bulls (30,000/month) and the corresponding rate for male steers (1.77 million/month) yields 1.8 million per month, or 21.6 million per year. Assuming that the number of female beef cattle born per year is also 21.6 million, the total number of beef animals born per year is 43.2 million.

The USDA-ADRS reported that the number of heifers slaughtered each year is 12.8 million. Assuming that both their natural death rate and their slaughter rate are similar to the corresponding rates for steers, the birth rate for cattle destined to be heifers is 1.2 million per month, or 14.4 million per year. Because the birth rate for female beef animals is assumed to be the same as it is for males, the birth rate for female beef cattle destined to become cows is 600,000 per month, or 7.2 million per year. We assume that beef cows have a natural death rate of 0.1% per month during their entire lives, but that their culling rate is approximately 5% annually between the ages of 24 and 47 months, and that after that time, their culling rate increases to 10% annually. These assumptions result in a beef cow population (*i.e.*, females ≥ 24 months of age) of approximately 50 million animals. This result is consistent with an annual birth rate of 43.2 million if it is assumed that each cow has an 85% chance of producing a calf each year.

Finally, we have specified separate age distributions for "beef" animals and "beef reproductive" animals. In particular, we assume that beef animals consist of beef steers, nonproductive beef heifers, and calves destined to be either of these. We assume that beef reproductive animals consist of beef cows, beef bulls, and calves destined to be either beef cows or beef bulls.

2.10 materializer

2.10.1 organDistribution

This parameter represents the proportion of a bovine's BSE infectivity in a specific organ as a function of time since infection. The table listing these proportions reflects a total incubation duration of 36 months. For animals with incubation periods other than 36 months, the time since infection is normalized before the organ infectivity distribution is identified. For example, if an animal has an incubation period of 72 months and it has been 40 months since infection occurred, the infectivity distribution referenced corresponds to the parameter entry for $(72 \div 36) \times 40 = 20$ months.

The base case base case assumes that during the first 50% of the incubation period, BSE infectivity is localized to the distal ileum. After that time, infectivity is localized to the spinal cord, trigeminal ganglia, and dorsal root ganglia, eyes, distal ileum, and brain.

References used to develop specific proportions include the following:

- (Wells et al., 1998)
- (Wells et al., 1999)
- SSC (1997). Listing of Specified Risk Materials: a scheme for assessing relative risk to man – Opinion of the Scientific Steering Committee adopted on 9 December 1997". http://europa.eu.int/comm/food/fs/sc/ssc/out22.en.html
- Gerald Bratton, Texas A&M, personal communication
- Gary Adams, Texas A&M, personal communication

2.10.2 totalInfectivity

This parameter represents the total amount of infectivity in an animal as a function of the time since infection. Infectivity is quantified as total number of oral ID_{50}s in the carcass. The table listing these values reflects a total incubation duration of 36 months. For animals with incubation periods other than 36 months, the time since infection is normalized before the total infectivity value is identified. For example, if an animal has an incubation period of 72 months and it has been 40 months since infection occurred, the total infectivity value referenced corresponds to the parameter entry for $(72 \div 36) \times 40 = 20$ months.

The base case values were developed based on the BSE pathogenesis study. The total quantity of infectivity in the animal at the end of the incubation period for the base case corresponds to the total amount of infectivity SEAC has suggested is in specified risk material. References used to develop base case values for this parameter include the following:

- (Wells et al., 1998)
- (Wells et al., 1999)
- (MAFF, 2000)

2.11 MBMTransporter

2.11.1 probDestination

This parameter specifies the probabilities that MBM will be sent to a prohibited feed producer, a non-prohibited feed producer, a mixed feed producer, or to some use (*e.g.,* export) that eliminates the possibility that the material will ultimately be fed to U.S. cattle. These probabilities depend on the type of MBM transporter. The specific values used for the base case were developed based on the assumption that MBM will not ultimately be consumed by cattle in the U.S. if it exported, used to produce pet food, or used to produce feed for other animals that are not considered to be livestock. We assume that most of the prohibited MBM not made available for use on farms in the U.S. is either used in pet food or is exported. References used to develop the base case assumptions included the following:

- Eastern Research Group, Inc, TSE Regulatory Options Cost Analysis, TSE, 1996, http://www.fda.gov/cvm/index/bse/tse1.pdf

- Biosafety and Risk Analysis for the use of Spray Dry Plasma and Other Blood Derivatives in Animal Feed. (Volume 1-Analysis) ACP Europe, October 1999

- Jeff Hansen, Swine Nutritionist, Murphy Farm, North Carolina

2.12 PMInspector

2.12.1 probPassPM

This parameter specifies the probability of passing post mortem inspection for each tissue. Data on specific condemnation rates are only available for liver and kidneys. The condemnation rates for liver and kidneys are both approximately 20%. We assume the condemnation rates for other organs and tissues range from 2% to 20%. Because lung tissue is not allowed in human food, all lungs are condemned at post mortem inspection. In addition, because emboli consist of CNS tissue, we assume that brain and spinal cord will be condemned in the event of emboli formation. The values depend on the animal's age and on whether there are emboli in a tissue. References used to develop the base case assumptions include the following:

- Nathan Bauer, USDA-FSIS personal communication

- Robert Brewer, USDA-FSIS personal communication

2.13 proteinInfector

Parameters belonging to the proteinInfector group pertain to animal protein produced by the rendering of cattle in the U.S. The randomInfector parameter group contains parameters pertaining to other sources of animal-based protein that may contain TSE infectivity (*e.g.,* imported protein or protein from animals other than bovines).

2.13.1 numCowsReceiving

This parameter represents the number of bovines among which rendered material from a single slaughtered animal is divided. The estimate is based on the assumption that a single batch of rendered material (4,000 pounds) is contained in feed that is sent to one farm. Dairy cattle consume an average of 3% of their body weight per day, or 30 pounds. A typical dairy ration consists of up to 5% animal protein, indicating that a single dairy animal will consume 1.5 pounds of animal protein per day. Hence, the 4,000 pounds of rendered animals protein represents approximately 2,667 daily rations. Assuming that the feed supply is consumed within 30 days of its purchase, the 2,667 rations will be divided among approximately 88 animals. These assumptions are based in part on the following references:

- Ensminger, ME; Oldfield, JE; Heinemann, WW (1990) "Feeds and Nutrition". The Ensminger Publishing Company, USA
- Conversations with the rendering industry
- Conversations with the representatives of the feed industry

2.13.2 probInfection

This parameter represents the probability that an animal will become infected with BSE after consuming a specified number of susceptibility-adjusted ID_{50}s. See the discussion of the probInfection parameter in parameter group bloodInfector.

2.13.3 consumption

This parameter represents the relative consumption of animal-based bypass protein for each bovine type, gender, age combination. These relative weights are proportional to the probability that an animal will ingest infectivity in feed supplemented by animal protein. These proportions are based on information from the following two references:

- Ensminger, ME; Oldfield, JE Heinemann, WW (1990) "Feeds and Nutrition". The Ensminger Publishing Company, USA
- National Research Council (1989). "Nutrient Requirements for dairy cattle, Sixth Revised Edition, Update 1989" Washington DC, US

2.13.4 susceptibility

This parameter quantifies the relative susceptibility of a bovine to BSE infection *via* oral exposure. See the discussion of the susceptibility parameter in parameter group bloodInfector.

2.14 randomInfector

Parameters belonging to the randomInfector group pertain to sources of animal-based protein other than domestically rendered cattle that may contain TSE infectivity (*e.g.*, imported protein or protein from animals other than bovines). The proteinInfector group pertains to animal protein produced by the rendering of cattle in the U.S. The randomInfector parameter group has the same parameters and same base case values as the proteinInfector group.

2.15 rateSlaughter

This parameter represents the probability that cattle will be sent to slaughter. This probability depends on the type of production, age and gender (*e.g*., steers and heifers are sent to slaughter earlier than dairy cows or reproductive beef animals. Our assumptions are based on the following data:

- USDA: ANIMAL DISPOSITION REPORTING SYSTEM ADRS) http://www.fsis.usda.gov/OPHS/adrsdata/1998adrs/adrsfy98.htm
- Radostits, OM, Leslie, KE, Fetrow, J (1994)" Herd Food Animal Production Medicine", Second Edition, WB Saunders Company
- John Clay, Dairy Records, personal communication
- Ken Crendell, DHI, personal communication
- Jody A. Pinter, AgSource Cooperative Services, personal communication

2.16 renderer

2.16.1 renderFactor

This parameter enumerates the set of render reduction factor values for plants in the U.S. that render cattle. The "render reduction factor" is the ratio of the amount of infectivity in the material sent into a rendering system to the amount of infectivity in the material produced by the rendering system. For example, a rendering system with a render reduction factor of 10 eliminates 90% of the infectivity in material that it processes. The renderFactor parameter also specifies the proportion of cattle in the U.S. that are processed using systems with each of the listed reduction factors.

The base case assumes that rendering plants fall into four groups: batch processing, (reduction factor of $10^{3.1}$), continuous processing with fat added (reduction factor of 10^2), continuous processing with no fat added (reduction factor of 10^1), and vacuum processing (no reduction in infectivity – *i.e.*, reduction factor of 10^0).

The simulation assumes that the type of processing used for each animal is independent of its type. The base case assumptions may understate the true reduction factor applicable to dairy cattle (which tend to live to an older age and therefore have a greater chance of developing BSE) because processing these animals requires the addition of fat, something which increases inactivation achieved by the widely used continuous processing systems.

The values used for this parameter are based on information from the following references:

- David W. Harlan, Taylor Byproducts, personal communication
- Dennis K. Mullane, Taylor Byproducts, personal communication
- (Taylor et al., 1995)
- (Taylor et al., 1997)

2.16.2 probContamination

This parameter represents the probability that a batch of prohibited MBM will contaminate a batch of non-prohibited MBM. Our estimate is based on the degree to which producers comply with FDA regulations designed to prevent commingling of prohibited and non-prohibited feed material. The values used for this parameter are based on the following references:

- FDA-BSE Enforcement activities-March 23, 2001
- Food and Drug Administration, Substances Prohibited From Use in Animal Food or Feed; Animal Proteins Prohibited in Ruminant Feed; Final Rule-21 CFR Part 589, 1997

2.16.3 probType

This parameter represents the probability that bovine material sent to rendering will be sent to a prohibited, non-prohibited, or mixed rendering plant. The base case assumes that 95%

of the time, cattle material is sent to prohibited rendering plants, 4.9999% of the time it is sent to mixed plants, and that very occasionally (0.0001% of the time), it is incorrectly sent to non-prohibited plants (*e.g*., facility producing either pure porcine or pure equine proteins). References for these assumptions include the following:

- David W. Harlan, Taylor Byproducts personal communication
- Dennis K. Mullane, Taylor Byproducts, personal communication
- Don Franco, National Renderers Association

2.16.4 probMisLabel

This parameter represents the probability that a prohibited or mixed renderer will mislabel prohibited MBM that it produces as non-prohibited. We estimate that mixed renderers and prohibited renderers mislabel 5% of their prohibited MBM as non-prohibited. This value was estimated jointly with the probability that feed producers mislabel their prohibited product. The basis for these estimates is described here.

Although the FDA feed ban (FDA, Final Rule-21 CFR Part 589) requires a prominent label to be placed on any product derived from rendered ruminants or mink to prevent its administration to bovines, the base case assumes that both MBM and feed falling into this category may be mislabeled at the production facility. FDA surveys provide only a partial indication of how frequently mislabeling might occur. In particular, FDA surveys record the fraction of <u>facilities</u> found to lack knowledge of or be out of compliance with the feed ban. This proportion may differ substantially from the fraction of <u>material</u> (MBM or feed) that is mislabeled. First, non-compliance may be more common among large producers than among small producers (which would mean that the fraction of mislabeled material exceeds the fraction of facilities out of compliance), or the reverse might be true. Second, if material is mislabeled in error (rather than purposely), it may still be treated as prohibited even though it is not labeled as such. For example, if a feed mill that makes only poultry feed using prohibited MBM neglects to label its product as prohibited, it is still likely that the feed will still be administered only to chicken, *i.e.,* no bovine exposure will result. If MBM produced by a prohibited renderer were contracted to a feed mill making prohibited feed, mislabeled material would still be used to make prohibited feed.

On the other hand, mislabeling can increase bovine exposure to prohibited protein. A substantial fraction of the MBM used to supplement feed is purchased as a bulk commodity, sometimes through protein blenders, and its provenance is unknown. In these cases, mislabeling could result in the incorrect use of prohibited material in the production of non-prohibited feed. Similarly, mislabeled feed could result in bovine exposure to ruminant MBM. There may be economic incentives that encourage mislabeling because prohibited MBM can be less expensive than animal protein sources. For example, in May, 2001, the Southern States Cooperative reported the following prices:

Table A2.16-1
Prices for Alternative Sources of Protein: May, 2001 (Southern States Cooperative)

Commodity	Price per Ton
Soy48	$177
MBM 50% crude ruminant protein	$210
MBM 58% crude swine protein	$238

Because survey information does not provide information directly relevant to estimation of the mislabeling rates, we have used a simple mass-balance approach to characterize the set of plausible rates. In particular, we estimate the total amount of mammalian protein used to make cattle feed and assume that the mislabeled MBM and feed makes up the difference between this total and the amount of pure porcine protein available. Appendix 1 Figure 2.15-1 summarizes the relationships assumed.

Material from ruminants and other prohibited species can either be labeled as prohibited MBM or mislabeled as non-prohibited MBM. The prohibited MBM can be exported, used to produce pet food, or used to produce prohibited feed. The prohibited feed may also be exported, or mislabeled as non-prohibited feed. Of the total porcine MBM produced, some fraction is exported or used for non-livestock feed. The rest is used to make non-prohibited feed. Non-prohibited feed made from porcine MBM supplies a portion of the protein needed by cattle. Other sources of protein include non-mammalian animal protein, like poultry feather meal, and vegetable protein, primarily from soy.

We estimate that 4.6 billion pounds of prohibited MBM and 1.5 billion pounds of porcine MBM are produced each year (Sparks Companies, 1997). The total annual use of the protein supplements in our model is 13.9 billion pounds and we assume 4.4% is supplied from porcine MBM (David W. Harlan, personal communication). Further, we assume that 32% of prohibited

MBM and 10% of porcine MBM is diverted to exports and pet food. We also assume that 75% of porcine MBM is used to produce feed for animals other than bovines. These assumptions imply 90 million pound annual shortfall of mammalian protein for cattle feed. We assume that this shortfall is made up by using both mislabeled MBM and mislabeled prohibited feed.

Because we have left the values of two parameters unspecified (*i.e.*, the proportion of prohibited materials mislabeled and the proportion of prohibited feed that is mislabeled), the assumptions described in the preceding paragraph imply a set of solutions that lie on a line when these two parameters are plotted in two dimensions. As illustrated in Appendix 1 Figure 2.15-2, assuming that no prohibited MBM is mislabeled implies that approximately 12% of prohibited feed is mislabeled. On the other hand, assuming that no prohibited feed is mislabeled implies that 8% of prohibited MBM is mislabeled. Other combinations that work are between these two extremes. Because we have no additional data suggesting which combinations are most likely, we have chosen an intermediate value. In particular, the base case assumes that the mislabeling rates for prohibited MBM and prohibited feed are both 5%.

2.16.5 fracContaminate

This parameter represents the fraction of infectivity in a batch of prohibited MBM that ends up in non-prohibited MBM if contamination occurs. Our estimate for this parameter is based on the assumption that flushing and cleaning procedures in a mixed mill leaves 0.1% of the prohibited materials behind by volume. This estimate reflects two sets of personal communications:

- David W. Harlan, Taylor Byproducts, personal communication
- Burt Pritchet, FDA, personal communication, based on regulation regarding cleaning procedures for medicated feed (based on FDA good manufacture guidelines for medicated feed and compliance with policy guidelines)

2.17 sickBovine

2.17.1 clinicalDate

This parameter describes the distribution of values for the duration (in months) between BSE infection and the manifestation of clinical signs. The base case assumes that the duration between infection and manifestation of clinical signs follows a distribution described inferred by Ferguson et al. (1997) (Ferguson et al., 1997) from data collected in the UK. In particular, Ferguson et al. considered the joint performance of distributions for both incubation duration and exposure/susceptibility. The incubation period distribution that performed the best was one that reflected disease mechanism considerations proposed by Medley and Short (1996) (Medley and Short, 1996). The Medley and Short model postulates exponential growth of infectivity in an infected animal until a threshold is reached and clinical signs become apparent. The density for the incubation duration, *f(t)*, has the form

$$f(t) = \left(\frac{\alpha_2 e^{-t/\alpha_1}}{\alpha_3} \right)^{\frac{\alpha_2^2}{\alpha_3}} e^{\frac{-\alpha_2 e^{-t/\alpha_1}}{\alpha_3}} .$$

The best-fit parameter values for the incubation period distribution corresponding to the best-fitting exposure/susceptibility distribution were reported by Ferguson et al. (1997) to be α_1 = 1.146, α_2 = 0.0241, and $\alpha_3 = 5.71 \times 10^{-4}$. The density is right-skewed with a median of approximately four years. The 5th percentile is approximately 2.5 years, the median is approximately four years, and the 95th percentile is approximately seven years.

References used to develop this distribution include the following:

- (Ferguson et al., 1997)
- (Medley and Short, 1996)

2.17.2 clinicalDuration

This parameter describes the distribution of values for the duration between the manifestation of clinical BSE signs and death. The base case assumes that this duration is uniformly distributed between 2 and 6 months. This assumption is based on a personal communication with Dr Dagmar Heim.

2.17.3 maternalContageousPoint

This parameter represents the proportion of the incubation period that must pass before a cow can transmit BSE to its calf. The base case assumes calves born to infected cows after five-sixths of the incubation period has elapsed will become infected with 10% probability. This assumption is based on the following references:

- MAFF, BSE Epidemiology, http://www.defra.gov.uk/animalh/bse/index.html
- SSC, Opinion on the possible vertical transmission of Bovine spongiform encephalopathy (BSE) adopted by the Scientific Steering Committee at its meeting of 18-19 March 1999 http://europa.eu.int/comm/food/fs/sc/ssc/out43_en.html

2.18 splitter

2.18.1 fracAerosol

This parameter quantifies the fraction of infectivity in the spinal cord that is aerosolized and deposited on edible meat during the splitting process. The base case value of 0.001%, which amounts to 2.5 mg of tissue, is based on data from experiments that measured the amount of spinal cord associated protein deposited on the carcass during splitting (Harbour, 2001). The base case also assumes that further treatment of the carcass (*e.g.*, steam cleaning or washing) does not remove any of the deposited infectivity. References used to develop the base case value for this assumption include the following:

- Chris Helps, Bristol University personal communication
- REMCORD study, EU, http://europa.eu.int/comm/research/press/1998/pr2710en.html
- EURORISK study, EU
- (Harbour, 2001)

2.18.2 probMS_AMR_SCRRemove

As noted in Section 3.1.2.7, the potential for infectivity in both the spinal cord and the dorsal root ganglia to contaminate edible meat depends on whether a mis-split occurs, whether the slaughter facility uses advanced meat recovery technology (AMR), and whether it removes the spinal cord. Section 3.1.2.7 in the main report describes the development of the joint distribution for these three factors. Table 2.17-1 summarizes the marginal probabilities for each factor and the joint probabilities for all factor combinations.

Table 2.18-1
Calculation of Probabilities for Combinations of Factors Influencing Contamination of Meat by Spinal Cord and Dorsal Root Ganglia

Age	Marginal Probabilities: Mis-Split	Marginal Probabilities: AMR	Marginal Probabilities: Spinal Cord Removal	AMR-SC Remove-MS	Joint Probability
0-11 Months	No – 95%	No – 100%	No – 50%	No-No-No	47.5%
			Yes – 50%	No-No-Yes	47.5%
		Yes – 0%	No – 2%	No-Yes-No	0%
			Yes – 98%	No-Yes-Yes	0%
	Yes – 5%	No – 100%	No – 50%	Yes-No-No	2.5%
			Yes – 50%	Yes-No-Yes	2.5%
		Yes – 0%	No – 2%	Yes-Yes-No	0%
			Yes – 98%	Yes-Yes-Yes	0%
12-23 Months	No – 95%	No – 35%	No – 50%	No-No-No	16.625%
			Yes – 50%	No-No-Yes	16.625%
		Yes – 65%	No – 2%	No-Yes-No	1.235%
			Yes – 98%	No-Yes-Yes	60.515%
	Yes – 5%	No – 35%	No – 50%	Yes-No-No	0.875%
			Yes – 50%	Yes-No-Yes	0.875%
		Yes – 65%	No – 2%	Yes-Yes-No	0.065%
			Yes – 98%	Yes-Yes-Yes	3.185%
≥ 24 months	No – 92%	No – 40%	No – 50%	No-No-No	18.4%
			Yes – 50%	No-No-Yes	18.4%
		Yes – 60%	No – 2%	No-Yes-No	1.104%
			Yes – 98%	No-Yes-Yes	54.096%
	Yes – 8%	No – 40%	No – 50%	Yes-No-No	1.6%
			Yes – 50%	Yes-No-Yes	1.6%
		Yes – 60%	No – 2%	Yes-Yes-No	0.096%
			Yes – 98%	Yes-Yes-Yes	4.704%

References used to develop the marginal probabilities include the following:

- Harold Hodges, BFD Corporation, personal communication
- Robert Bolin, ConAgra Beef Company, personal Communication
- Sherri Kochevar, ConAgra Beef Company, personal Communication

- Robert Brewer, USDA-FSIS, personal Communication
- Nathan Bauer, USDA-FSIS, personal Communication
- Craig White, USDA-FSIS, personal Communication
- Sparks Companies, Inc. Advanced Meat Recovery Systems-An Economic Analysis of the Proposed USDA Regulation, 1999

2.18.3 fracSCInMuscle, fracSCInAMRMeat, and fracSCInBone

These parameters quantify the fraction of spinal cord infectivity that contaminates muscle meat, AMR product, and meat on bone. These fractions all depend on the age of the animal, whether a mis-split occurs, whether the slaughter facility uses advanced meat recovery technology (AMR), and whether it removes the spinal cord.

Animals less than 12 months

The amount of infectivity in the spinal cord of these animals is likely to be small because the incubation period is longer than 12 months and substantial infectivity does not develop in the spinal cord until a substantial portion of the incubation period passes. For example, the probability that the incubation period is no longer than 18 months is less than 1%. An animal infected at birth and slaughtered at age 12 months would have survived two-thirds of that period. At the time of the animal's death in this case, there would be less than 0.5 ID_{50}s in the animal's spinal cord. If the incubation period is longer than 18 months, then the amount of infectivity in the spinal cord will be even less than 0.5 ID_{50}s.

Animals 12 – 23 months

At facilities that remove spinal cords, successful spinal cord removal prevents contamination by infectivity in spinal cord of muscle meat (other than that caused by aerosolization during splitting), AMR product, and beef in bone cuts. If a mis-split occurs, it affects a 5 cm length of spinal cord in the neck area. Of this 5 cm length, which represents 5 ÷ 210 cm = 2.4% of the spinal cord, half is easily removed from the carcass and sent to rendering, while the other half is sent to AMR processing. Of the half sent to AMR processing, we assume half contaminates the AMR product, or approximately 0.6% of the infectivity in the total spinal cord. In facilities that do not use AMR, all of the infectivity in the mis-split segment goes to rendering. Whether or not there is AMR, there is no contamination of either muscle meat or beef on bone in facilities that remove the spinal cord.

At facilities that do not remove spinal cords but do use AMR, we assume that 30% of the spinal column ends up in beef on bone cuts of meet. Another 0.1% contaminates muscle meat. If there is no mis-split, then the remaining 69.9% is sent to AMR. Of this, approximately half (35% of the total spinal cord) contaminates the AMR product. If there is a mis-split, then half of the 5 cm mis-split segment (a 2.5 cm segment) remains in the carcass and is ultimately rendered. Because we assume that half of the spinal cord processed by AMR ultimately contaminates AMR product, the loss of 2.5 cm of spinal cord reduces AMR contamination by $50\% \times 2.5$ cm $\div$ 210 cm, or approximately 0.6%. Hence, if there is a mis-split, contamination of AMR product is 35% - 0.6%, or 34.4%.

Finally, at facilities that do not remove spinal cord and do not use AMR, we assume that 30% of the spinal cord ends up in beef on bone cuts of meat and another 0.1% contaminates muscle meat.

Animals ≥ 24 months

Animals in this age group differ from those between the ages of 12 and 23 months in three respects. First, the spinal cord is assumed to be 225 cm. Second, the length of spinal cord assumed to be affected by a mis-split is assumed to be 8 cm in length. Finally, we assume that animals 24 months of age and older do not produce any meat on bone cuts. Hence, contamination can potentially affect only AMR meat and muscle meat.

At facilities that remove spinal cords, a mis-split can contaminate AMR with one-fourth of the infectivity in the 8 cm mis-split segment, or approximately 0.9% of the infectivity in the total spinal cord. No muscle meat contamination occurs.

At facilities that do not remove spinal cords but do use AMR, the entire spinal column is potentially available for AMR processing because there are no on bone cuts of meat. If no mis-split occurs, then we assume approximately 50% of the infectivity in the spinal cord contaminates the AMR product. If a mis-split does occur, then 50% of the 8 cm mis-split segment is rendered.

Because half of that would have contaminated the AMR product in the absence of the mis-split, spinal cord contamination of the AMR product is reduced by 25% × 8 cm ÷ 225 cm, or approximately 0.9%. That is, 49.1% of the spinal cord's infectivity contaminates AMR product. As in the case of animals between the ages of 12 and 23 months, we assume that 0.1% of the spinal cord infectivity contaminates muscle meat.

Finally, at facilities that that neither remove spinal cords nor use AMR, the only contamination is the 0.1% of spinal cord infectivity that contaminates muscle meat.

2.18.4 fracDRGInMuscle, fracDRGInAMRMeat, and fracDRGInBone

These parameters quantify the fraction of dorsal root ganglia infectivity that contaminates muscle meat, AMR product, and meat on bone. These fractions all depend on the age of the animal, whether a mis-split occurs, whether the slaughter facility uses advanced meat recovery technology (AMR), and whether it removes the spinal cord.

Animals less than 12 months

Because the amount of infectivity in the DRG of animals this age group is almost certainly small (see the discussion of this age group in Section 2.17.3), the base case assumes that the DRG does not contaminate any meat products or cuts of meat.

Animals 12 – 23 months

For animals in this age group, DRG can potentially contaminate muscle meat, AMR product, and on bone cuts of meat. When the spinal cord is not removed, the base case assumes that 0.1% of the infectivity in DRG is transferred to muscle meat. Otherwise, the base case assumes that no infectivity is transferred from DRG to muscle meat.

At facilities using AMR, AMR processes 70% of the backbone. The remaining 30% remains part of the on bone cuts of meat. The base case assumes that half of the DRG infectivity associated with the backbone portion processed using this technology ultimately contaminates the AMR product (*i.e.*, 35% of the total DRG infectivity originally in the animal).

Finally, the base case assumes that the 30% of DRG infectivity associated with the on-bone cuts of meat ultimately remain with those cuts of meat.

Animals ≥ 24 months

Assumptions for animals in this age group are similar to those developed for animals between the ages of 12 and 23 months. The main difference is the assumption that there are no on-bone cuts of meat recovered from animals that are at least 24 months of age. As a result, in facilities that use AMR, the entire backbone is processed and 50% of the original DRG infectivity contaminates AMR product. At facilities that do not remove spinal cord, 0.1% of the DRG infectivity contaminates muscle meat. Finally, because no on-bone cuts of meat are recovered from these animals, none of the DRG infectivity ends up in this category of meat.

2.19 Stunner

2.19.1 probDrip

This parameter quantifies the probability that brain tissue will drip from the hole created by the stunner, contaminating blood drained from the carcass. We assume that this contamination can potentially affect only blood being collected for the manufacture of animal blood meal. Blood being collected for human consumption is assumed to be safe from contamination because of extra precautions taken. The base case assumes that this phenomenon can occur only if an air injected pneumatic stunner is used. In that case, we assume that brain tissue drips from the stunner hole with a probability of 30%. References used to develop this set of assumptions include the following:

- Nathan Bauer, USDA-FSIS, personal Communication
- Dr Craig Shultz, USDA-FSIS personal communication

2.19.2 fracDrip

This parameter represents the fraction of brain infectivity that contaminates blood if tissue drips from the stunner hole. The base case assumes that 20 grams of brain can drip from the stunner hole, which amounts to 4% of the brain. References used to develop this assumption include the following:

- Nathan Bauer, USDA-FSIS, personal Communication
- Dr Craig Shultz, USDA-FSIS personal communication

2.19.3 probType

This parameter quantifies the proportion of cattle stunned using each type of stunning technology. The base case assumes that air-injected pneumatic stunners are not used at this time. References used to develop this assumption include the following:

- Nathan Bauer, USDA-FSIS, personal Communication
- Robert Brewer, USDA-FSIS, personal Communication
- Craig White, USDA-FSIS, personal Communication
- USDA-FSIS Cattle stunning memo, February 2000

2.19.4 probOK

This parameter quantifies the probability that a specific type of stunner functions correctly. We assume that only air-injected pneumatic stunners can malfunction in a way that influences the probability of emboli formation. References used to develop the estimates for this set of parameters include:

- Nathan Bauer, USDA-FSIS, personal Communication
- Craig Shultz, USDA-FSIS personal communication
- (Anil et al., 1999)
- (Garland et al., 1996)
- (Schmidt et al., 1999b)

2.19.5 emboli

This parameter quantifies for each tissue both the probability that it will be contaminated by emboli and how much contamination might occur. Only limited measurements of emboli production following stunning have been reported. Anil *et al*, 1999 (Anil et al., 1999) measured the presence of Syntaxin 1-B (an integral membrane protein abundant in the nervous tissue) and Annexin V (an endogenous cytoplasmatic protein used as a marker of cellular damage, including CNS) in blood collected from the jugular vein of cattle stunned with pneumatically operated air injection penetrating captive bolt, penetrating cartridge, and non penetrating cartridge. Schmidt et al., 1999 (Schmidt et al., 1999a) evaluated the presence of clots in heart after the use of pneumatic power stunners, pneumatic-power air-injection stunners, and cartridge fire stunners. Emboli have been macroscopically found in the blood, heart, lung and liver.

For each organ, we specify both the probability that there will be any emboli and the fraction of brain tissue that is deposited in that tissue (described as a range of possible values) if emboli are created. Values for these parameters are estimated from data reported by Anil *et al* (1999). The lower bound estimate for the fraction of CNS tissue deposited in blood corresponds to the limit of detection in the Anil *et al* (1999) analysis, as calculated by Chris Helps (personal communication). Because no data have been reported for the other organs/tissues, the base case assumptions are based on the judgment of field investigators (Nathan Bauer; Craig Shultz, personal communication). In particular, the base case assumes that for stunners that do not use air injection, the upper bound on the amount of CNS tissue deposited in each organ/tissue corresponds to the limit of detection calculated for the Anil *et al* (1999) study. The lower bound value for this quantity is 10% of the upper bound value. The one exception to this set of assumptions is the heart. For that organ, it is assumed that extensive washing in the slaughterhouse eliminates all CNS emboli.

References used to develop the estimates for this set of parameters include:

- Nathan Bauer, USDA-FSIS, personal communication
- Craig Shultz, USDA-FSIS personal communication
- (Anil et al., 1999)
- (Garland et al., 1996)

- (Schmidt et al., 1999b)

2.20 Other Parameters

2.20.1 farmDeathDisp

This parameter quantifies the probability that cattle that died on the farm will be disposed of by rendering. The base case scenario assumes that 85% of the cattle dying on the farm are processed by rendering. Animals not rendered are assumed to be disposed of in a manner that makes them unavailable to expose other cattle. References used to develop the estimates for this parameter include:

- Don Franco, National Renderers Association, personal communication
- David W. Harlan, Taylor Byproducts, personal communication.
- Linda Detwiler, USDA, personal communication.

3 Base Case Parameter Values

3.1 AMInspector

3.1.1 probPassAM

Animal's Clinical Status	Age in Months	Probability of Passing AM Inspection
Animal has no clinical BSE signs	Birth to 11	0.990173
	12 to 23	0.99993
	≥ 24	0.997244
Animal does have clinical BSE signs	All ages	0.1

3.2 birthVisitor

3.2.1 probBirth

Monthly probability of giving birth to a calf: 0.0833

3.2.2 probTrans

Probability of BSE transmission from mother to calf during end stage of disease: 0.1

3.2.3 beginCalving

Age in months when female cattle start calving: 24

3.2.4 endCalving

Maximum age at which female cattle can calve: 180

3.3 bloodInfector

3.3.1 numCowsRecieving

Number of cattle receiving one batch of blood meal: 89

3.3.2 probInfection

Number of susceptibility-adjusted ID_{50}s Ingested	Probability of Infection[a]
0	0
1	0.5
≥ 2	1.0

Notes:

a. *Intermediate values are linearly interpolated. For example, the probability of infection is 0.25 if 0.5 susceptibility-adjusted ID_{50}s are ingested.*

3.3.3 consumption

Cattle Type	Gender	Age in Months	Relative Consumption of Blood Meal
Beef	Male	0 to 7	0
		8	2
		9	2.2
		10	2.4
		11	2.6
		12	2.8

Cattle Type	Gender	Age in Months	Relative Consumption of Blood Meal
		13	2.8
		14	2.8
		15 to 238	0
		≥ 239	0
	Female	0 to 7	0
		8	2
		9	2.4
		10	2.6
		11	2.8
		12	2.8
		13	2.8
		14	2.8
		15 to 166	0
		≥ 167	0
Reproductive Beef	Male	0 to 238	0
		≥ 239	0
	Female	0 to 238	0
		≥ 239	0
Dairy	Male	0 to 6	0
		7 to 12	1
		13 to 168	1.5
		≥ 169	0
	Female	0	2.5
		1 to 2	5
		3	6
		4	7
		5	1.6
		6	1.8
		7	2
		8	2.1
		9	2.2
		10	2.3
		11	2.4
		12	2.5
		13 to 22	0
		23	10
		24	15
		25	17.5
		26 to 27	22.5
		28	20
		29	17.5
		30 to 32	10

Appendix 1

Cattle Type	Gender	Age in Months	Relative Consumption of Blood Meal
		33	5
		34	0
		35	10
		36	15
		37	17.5
		38 to 39	22.5
		40	20
		41	17.5
		42 to 44	10
		45	5
		46	0
		47	10
		48	15
		49	17.5
		50 to 51	22.5
		52	20
		53	17.5
		54 to 56	10
		57	5
		58	0
		59	10
		60	15
		61	17.5
		62 to 63	22.5
		64	20
		65	17.5
		66 to 68	10
		69	5
		70	0
		71	10
		72	15
		73	17.5
		74 to 75	22.5
		76	20
		77	17.5
		78 to 80	10
		81	5
		82	0
		83	10
		84	15
		85	17.5
		86 to 87	22.5
		88	20
		89	17.5
		90 to 92	10
		93	5
		94	0

Appendix 1

Cattle Type	Gender	Age in Months	Relative Consumption of Blood Meal
		95	10
		96	15
		97	17.5
		98 to 99	22.5
		100	20
		101	17.5
		102 to 104	10
		105	5
		106	0
		107	10
		108	15
		109	17.5
		110 to 111	22.5
		112	20
		113	17.5
		114 to 116	10
		117	5
		118	0
		119	10
		120	15
		121	17.5
		122 to 123	22.5
		124	20
		125	17.5
		126 to 128	10
		129	5
		130	0
		131	10
		132	15
		133	17.5
		134 to 135	22.5
		136	20
		137	17.5
		138 to 140	10
		141	5
		142	0
		143	10
		144	15
		145	17.5
		146 to 147	22.5
		148	20
		149	17.5
		150 to 152	10
		153	5
		154	0
		155	10
		156	15

Cattle Type	Gender	Age in Months	Relative Consumption of Blood Meal
		157	17.5
		158 to 159	22.5
		160	20
		161	17.5
		162 to 164	10
		165	5
		166	0
		167	10
		168	15
		169	17.5
		170 to 171	22.5
		172	20
		173	17.5
		174 to 176	10
		177	5
		178	0
		179	10
		180	15
		181	17.5
		182 to 183	22.5
		184	20
		185	17.5
		186 to 188	10
		189	5
		190	0
		191	10
		192	15
		193	17.5
		194 to 195	22.5
		196	20
		197	17.5
		198 to 200	10
		201	5
		202	0
		203	10
		204	15
		205	17.5
		206 to 207	22.5
		208	20
		209	17.5
		210 to 212	10
		213	5
		214	0
		215	10
		216	15
		217	17.5
		≥ 218	22.5

3.3.4 Susceptibility

Age in Months	Relative Susceptibility to Infection
0	1
4	1.024151
5	0.882277
6	0.762183
7	0.660526
8	0.574475
9	0.501634
10	0.439976
11	0.387784
12	0.343604
13	0.306206
14	0.27455
15	0.247753
16	0.22507
17	0.20587
18	0.189617
19	0.175859
20	0.164213
21	0.154355
22	0.146011
23	0.138947
24	0.132968
25	0.127907
26	0.123623
27	0.119996
28	0.116926
29	0.114328
30	0.112128
31	0.110266
32	0.10869
33	0.107356
34	0.106227
35	0.105271
36	0.104462
37	0.103777
38	0.103197
39	0.102706
40	0.102291
41	0.101939
42	0.101641
43	0.101389
44	0.101176
45	0.100996
46	0.100843

Age in Months	Relative Susceptibility to Infection
47	0.100713
48	0.100604
49	0.100511
50	0.100433
51	0.100366
52	0.10031
53	0.100262
54	0.100222
55	0.100188
56	0.100159
57	0.100135
58	0.100114
59	0.100097
60	0.100082
61	0.100069
62	0.100059
63	0.10005
64	0.100042
65	0.100036
66	0.10003
67	0.100025
68	0.100022
69	0.100018
70	0.100015
71	0.100013
72	0.100011
73	0.100009
74	0.100008
75	0.100007
76	0.100006
77	0.100005
78	0.100004
79	0.100003
80	0.100003
81	0.100002
82	0.100002
83	0.100002
84 to 90	0.100001
≥ 91	0.1

3.4 deathVisitor

3.4.1 probDeath

Age	Probability of Death
0	0
1	0.05
2	0.001

Age	Probability of Death
3-34	0.0015
35-40	0.003
41-60	0.01
61-239	1

3.5 feeder

3.5.1 probFeedOK

Probability that correctly labeled prohibited feed that reaches the farm will be not fed to cattle: 0.984

3.6 feedProducer

3.6.1 probFeedType

Type of MBM	FeedType	Proportion
Prohibited MBM	Prohibited Feed	1
	Non Prohibited Feed	0
Non Prohibited MBM	Prohibited Feed	0
	Non Prohibited Feed	1

3.6.2 probMislabel

Feed Producer Type	Probability of Mislabel
Prohibited Feed Producer	0.05
Non Prohibited Feed Producer	0
Mixed Feed Producer	0.05

3.6.3 probContaminate

Feed Producer Type	Probability of Contamination
Prohibited Feed Producer	0
Non Prohibited Feed Producer	0
Mixed Feed Producer	0.16

3.6.4 fracContaminate

Fraction of Prohibited MBM that could contaminate Non Prohibited MBM is 0.001

3.7 feedtransporter

3.7.1 probDestination

Type of Producer	Type of Material	Destination	Probability
Prohibited Feed Producer	Prohibited Feed	Farm	0.98
		Out	0.02
	Non Prohibited Feed	Farm	0.25
		Out	0.75
Non Prohibited Feed	Prohibited Feed	Farm	0
		Out	1
	Non Prohibited Feed	Farm	0.25
		Out	0.75
Mixed Feed Producer	Prohibited Feed	Farm	0.98
		Out	0.02
	Non Prohibited Feed	Farm	0.25
		Out	0.75
Blood Producer	Blood	Farm	0.15
		Out	0.85

3.8 foodInspector

3.8.1 probPassFood

Tissue /Organs	Probability of Passing into food
Brain	0.01
Spinal Cord	0.01
Dorsal Root Ganglia	0
Blood	0.05
Distal Ileum	0.01
Heart	0.5
Lung	0

Liver	0.6
Kidney	0.25
Eyes	0.001
Muscle	0.98
Bone	0.98
Trigeminal Ganglia	0

3.9 genesisvisitor

3.9.1 initSize

Type	Gender	Age	Population
Beef	Male	0	1688215
		1	1598215
		2	1595109
		3	1593402
		4	1591696
		5	1589993
		6	1588291
		7	1586591
		8	1584893
		9	1583196
		10	1581501
		11	1579808
		12	1578116
		13	1493271
		14	1412418
		15	1260785
		16	1124436
		17	1001827
		18	891571
		19	792421
		20	615304
		21	473724
		22	360533
		23	270032
		24	90123
		≥ 25	0
	Female	0	1152461
		1	1151261
		2	1150062
		3	1148265
		4	1146469
		5	1144675
		6	1142883
		7	1141092
		8	1139304

Appendix 1

Type	Gender	Age	Population
		9	1137517
		10	1135732
		11	1133948
		12	1132167
		13	1071103
		14	1013124
		15	904681
		16	807132
		17	719375
		18	640423
		19	569386
		20	442760
		21	341469
		22	260418
		23	195542
		24	66921
		≥ 25	0
Beef Reproductive	Male	0 to 25	111785
		26	22032
		27	21545
		28	21069
		29	20603
		30	20148
		31	19703
		32	19267
		33	18841
		34	18410
		35	17966
		36	17533
		37	17111
		38	16698
		39	16296
		40	15903
		41	15520
		42	15146
		43	14767
		44	14398
		45	14038
		46	13687
		47	13345
		48	13011
		49	12686
		50	12369
		51	12060
		52	11758
		53	11464
		54	11178

Appendix 1

Type	Gender	Age	Population
		55	10889
		56	10608
		57	10335
		58	10068
		59	9808
		60	9555
		61	9309
		62	9068
		63	8834
		64	8607
		65	8384
		66	8161
		67	7944
		68	7733
		69	7527
		70	7327
		71	7132
		72	6943
		73	6758
		74	6578
		75	6403
		76	6233
		77	6067
		78	5900
		79	5738
		80	5580
		81	5427
		82	5277
		83	5132
		84	4991
		85	4854
		86	4720
		87	4591
		88	4464
		89	4342
		90	4219
		91	4099
		92	3983
		93	3871
		94	3761
		95	3655
		96	3551
		97	3451
		98	3353
		99	3258
		100	3166
		101	3076
		102	2989

Type	Gender	Age	Population
		103	2905
		104	2822
		105	2743
		106	2665
		107	2590
		108	2516
		109	2445
		110	2376
		111	2309
		112	2243
		113	2180
		114	2118
		115	2058
		116	2000
		117	1943
		118	1888
		119	1835
		120	1783
		121	1733
		122	1683
		123	1636
		124	1590
		125	1545
		126	1501
		127	1458
		128	1417
		129	1377
		130	1338
		131	1300
		132	1263
		133	1228
		134	1193
		135	1159
		136	1126
		137	1094
		138	1063
		139	1033
		140	1004
		141	976
		142	948
		143	921
		144	895
		145	870
		146	845
		147	821
		148	798
		149	775
		150	754

Type	Gender	Age	Population
		151	732
		152	712
		153	691
		154	672
		155	653
		156	634
		157	616
		158	599
		159	582
		160	566
		161	549
		162	534
		163	519
		164	504
		165	490
		166	476
		167	463
		168	449
		169	437
		170	424
		171	412
		172	401
		173	389
		174	378
		175	368
		176	357
		177	347
		178	337
		179	328
		180	318
		181	309
		182	301
		183	292
		184	284
		185	276
		186	268
		187	260
		188	253
		189	246
		190	239
		191	232
		192	226
		193	219
		194	213
		195	207
		196	201
		197	195
		198	190

Appendix 1

Type	Gender	Age	Population
		199	185
		200	179
		201	174
		202	169
		203	165
		204	160
		205	155
		206	151
		207	147
		208	143
		209	139
		210	135
		211	131
		212	127
		213	123
		214	120
		215	117
		216	113
		217	110
		218	107
		219	104
		220	101
		221	98
		222	95
		223	93
		224	90
		225	88
		226	85
		227	83
		228	80
		229	78
		230	76
		231	74
		232	72
		233	70
		234	68
		235	66
		236	64
		237	62
		238	60
		239	59
		≥ 240	0
	Female	0 to 25	647539
		26	580888
		27	577887
		28	574901
		29	571931

Appendix 1

Type	Gender	Age	Population
		30	568976
		31	566036
		32	563112
		33	560202
		34	557308
		35	554429
		36	551564
		37	548714
		38	545879
		39	543059
		40	540253
		41	537462
		42	534685
		43	531922
		44	529174
		45	526440
		46	523720
		47	521014
		48	518322
		49	513485
		50	508692
		51	503944
		52	499241
		53	494581
		54	489965
		55	485392
		56	480862
		57	476374
		58	471928
		59	467523
		60	463159
		61	458837
		62	454554
		63	450312
		64	446109
		65	441945
		66	437820
		67	433734
		68	429686
		69	425675
		70	421702
		71	417766
		72	413867
		73	410005
		74	406178
		75	402387
		76	398631
		77	394911

Appendix 1

Type	Gender	Age	Population
		78	391225
		79	387573
		80	383956
		81	380372
		82	376822
		83	373305
		84	369821
		85	366369
		86	362950
		87	359562
		88	356207
		89	352882
		90	349588
		91	346326
		92	343093
		93	339891
		94	336719
		95	333576
		96	330463
		97	327378
		98	324323
		99	321296
		100	318297
		101	315326
		102	312383
		103	309468
		104	306579
		105	303718
		106	300883
		107	298075
		108	295293
		109	292537
		110	289806
		111	287102
		112	284422
		113	281767
		114	279138
		115	276532
		116	273951
		117	271394
		118	268861
		119	266352
		120	263866
		121	261403
		122	258964
		123	256547
		124	254152
		125	251780

Type	Gender	Age	Population
		126	249430
		127	247102
		128	244796
		129	242511
		130	240248
		131	238005
		132	235784
		133	233583
		134	231403
		135	229243
		136	227104
		137	224984
		138	222884
		139	220804
		140	218743
		141	216702
		142	214679
		143	212675
		144	210690
		145	208724
		146	206776
		147	204846
		148	202934
		149	201040
		150	199164
		151	197305
		152	195463
		153	193639
		154	191832
		155	190041
		156	188267
		157	186510
		158	184770
		159	183045
		160	181337
		161	179644
		162	177967
		163	176306
		164	174661
		165	173031
		166	171416
		167	169816
		≥ 168	0
Dairy	Male	0	290000
		1	275500
		2	96425
		3	67401

Appendix 1

Type	Gender	Age	Population
		4	53853
		5	45722
		6	38818
		7	32956
		8	27980
		9	23755
		10	20168
		11	17123
		12	14537
		13	12342
		14	12175
		15	12011
		16	11849
		17	11689
		18	11531
		19	11375
		20	11222
		21	11070
		22	10918
		23	10767
		24	10618
		25	10384
		26	10154
		27	9930
		28	9710
		29	9496
		30	9286
		31	9081
		32	8880
		33	8684
		34	8485
		35	8280
		36	8081
		37	7886
		38	7696
		39	7511
		40	7330
		41	7153
		42	6980
		43	6806
		44	6636
		45	6470
		46	6308
		47	6150
		48	5997
		49	5847
		50	5701
		51	5558

Appendix 1

Type	Gender	Age	Population
		52	5419
		53	5284
		54	5152
		55	5019
		56	4889
		57	4763
		58	4640
		59	4520
		60	4404
		61	4290
		62	4180
		63	4072
		64	3967
		65	3864
		66	3762
		67	3661
		68	3564
		69	3469
		70	3377
		71	3287
		72	3200
		73	3115
		74	3032
		75	2951
		76	2873
		77	2796
		78	2719
		79	2645
		80	2572
		81	2501
		82	2432
		83	2365
		84	2300
		85	2237
		86	2176
		87	2116
		88	2058
		89	2001
		90	1944
		91	1889
		92	1836
		93	1784
		94	1733
		95	1684
		96	1637
		97	1590
		98	1545
		99	1502

Appendix 1

Type	Gender	Age	Population
		100	1459
		101	1418
		102	1378
		103	1339
		104	1301
		105	1264
		106	1228
		107	1193
		108	1160
		109	1127
		110	1095
		111	1064
		112	1034
		113	1005
		114	976
		115	949
		116	922
		117	896
		118	870
		119	846
		120	822
		121	798
		122	776
		123	754
		124	733
		125	712
		126	692
		127	672
		128	653
		129	635
		130	617
		131	599
		132	582
		133	566
		134	550
		135	534
		136	519
		137	504
		138	490
		139	476
		140	463
		141	450
		142	437
		143	425
		144	413
		145	401
		146	390
		147	379

Appendix 1

Type	Gender	Age	Population
		148	368
		149	357
		150	347
		151	337
		152	328
		153	319
		154	310
		155	301
		156	292
		157	284
		158	276
		159	268
		160	261
		161	253
		162	246
		163	239
		164	232
		165	226
		166	219
		167	213
		168	207
		169	201
		≥ 170	0
	Female	0	290000
		1	274098
		2	259069
		3	258335
		4	257603
		5	256873
		6	256145
		7	255419
		8	254696
		9	253974
		10	253254
		11	252537
		12	251821
		13	251108
		14	250396
		15	249687
		16	248147
		17	246617
		18	245096
		19	243585
		20	242082
		21	240590
		22	236500
		23	232479

Appendix 1

Type	Gender	Age	Population
		24	228527
		25	224642
		26	220576
		27	216584
		28	212663
		29	208814
		30	205035
		31	201324
		32	197680
		33	194102
		34	190265
		35	186504
		36	182817
		37	179204
		38	175661
		39	172189
		40	168786
		41	165449
		42	162179
		43	158973
		44	155831
		45	152751
		46	149731
		47	146771
		48	143870
		49	140787
		50	137769
		51	134816
		52	131927
		53	129099
		54	126332
		55	123624
		56	120975
		57	118382
		58	115844
		59	113362
		60	110932
		61	108092
		62	105325
		63	102628
		64	100001
		65	97441
		66	94947
		67	92516
		68	90148
		69	87840
		70	85591
		71	83400

Appendix 1

Type	Gender	Age	Population
		72	81265
		73	78846
		74	76499
		75	74222
		76	72013
		77	69869
		78	67789
		79	65771
		80	63814
		81	61914
		82	60071
		83	58283
		84	56548
		85	54017
		86	51598
		87	49289
		88	47082
		89	44974
		90	42961
		91	41038
		92	39201
		93	37446
		94	35769
		95	34168
		96	32639
		97	31177
		98	29782
		99	28449
		100	27175
		101	25958
		102	24796
		103	23686
		104	22626
		105	21613
		106	20646
		107	19721
		108	18838
		109	17995
		110	17190
		111	16420
		112	15685
		113	14983
		114	14312
		115	13671
		116	13059
		117	12475
		118	11916
		119	11383

Type	Gender	Age	Population
		120	10873
		121	10386
		122	9922
		123	9477
		124	9053
		125	8648
		126	8261
		127	7891
		128	7538
		129	7200
		130	6878
		131	6570
		132	6276
		133	5995
		134	5727
		135	5470
		136	5225
		137	4991
		138	4768
		139	4554
		140	4351
		141	4156
		142	3970
		143	3792
		144	3622
		145	3460
		146	3305
		147	3157
		148	3016
		149	2881
		150	2752
		151	2629
		≥ 152	0

3.10 materializer

3.10.1 organDistribution

Months Post Infection[a]	Organ	Proportion of Animal's Total Infectivity
0 to 18	Distal Ileum	0
≥ 19	Brain	0.6446
	Spinal Cord	0.256
	Distal Ileum	0.033
	Dorsal Root Ganglia	0.04

Months Post Infection[a]	Organ	Proportion of Animal's Total Infectivity
	Eyes	0.0004
	Trigeminal Ganglia	0.026

Notes:

a. *This table reflects a total incubation duration of 36 months. For animals with incubation periods other than 36 months, the time since infection is normalized before the organ infectivity distribution is identified. For example, if an animal has an incubation period of 72 months and it has been 40 months since infection occurred, the infectivity distribution referenced corresponds to the parameter entry for* $(72 \div 36) \times 40 = 20$ *months.*

3.10.2 totalInfectivity

Months Post Infection	Total Cattle Oral ID_{50}s in Animal Infectivity
0	0
1 to 5	8
6 to 18	256
19	0.03
20	0.07
21	0.15
22	0.31
23	0.64
24	1.35
25	2.83
26	5.95
27	12.51
28	26.29
29	55.24
30	116.09
31	243.97
32	512.71
33	1077.47
34	2264.31
35	4758.48
36	10000

Notes:

a. *This table reflects a total incubation duration of 36 months. For animals with incubation periods other than 36 months, the time since infection is normalized before the organ infectivity distribution is identified. For example, if an animal has an incubation period of 72 months and it has been 40 months since infection occurred, the total infectivity value referenced corresponds to the parameter entry for* $(72 \div 36) \times 40 = 20$ *months.*

3.11 MBMtransporter

3.11.1 probDestination

Producer Type	Material	Destination	Probability
Prohibited	Prohibited MBM	Prohibited Feed Producer	0.63
		Non Prohibited Feed Producer	0
		Mixed Feed Producer	0.05
		Out[a]	
	Non-Prohibited MBM	Prohibited Feed Producer	0.63
		Non Prohibited Feed Producer	0
		Mixed Feed Producer	0.05
		Out[a]	
Non-Prohibited	Prohibited MBM	Prohibited Feed Producer	0
		Non Prohibited Feed Producer	0
		Mixed Feed Producer	0
		Out[a]	
	Non-Prohibited MBM	Prohibited Feed Producer	0
		Non Prohibited Feed Producer	0.85
		Mixed Feed Producer	0.05
		Out	
Mixed	Prohibited MBM	Prohibited Feed Producer	0.63
		Non Prohibited Feed Producer	0
		Mixed Feed Producer	0.05
		Out[a]	
	Non-Prohibited MBM	Prohibited Feed Producer	0
		Non Prohibited Feed Producer	0.85
		Mixed Feed Producer	0.05
		Out[a]	
Any	Blood	Blood Meal Producer	1
		Out[a]	0

Notes:

a. “Out” refers to destinations and applications that do not pose any risk of exposure to cattle or humans.

2.12 PMInspector

3.12.1 ProbPassPM

Age	Detectable Emboli	Organ	Probability of Passing Inspection
All Ages	No	Brain	0.9
		Spinal	0.9
		Drg	0.9
		Blood	0.98
		Heart	0.8
		Lung	0
		Liver	0.8
		Kidney	0.8
		Illeum	0.8
		Eyes	0.8
		Muscle	0.98
		Bone	0.98
		Trigeminal Ganglia	0.98
	Yes	Brain	0
		Spinal	0
		Drg	0.9
		Blood	0.98
		Heart	0.8
		Lung	0
		Liver	0.8
		Kidney	0.8
		Illeum	0.8
		Eyes	0.8
		Muscle	0.98
		Bone	0.98
		Trigeminal Ganglia	0.98

3.13 proteinInfector

3.13.1 probInfection

See probInfection for the bloodInfector (Section 3.3.1).

3.13.2 numCowsReceiving

Number of cattle receiving one batch of feed containing mammalian protein: 89.

3.13.3 consumption

Cattle Type	Gender	Age in Months	Relative Consumption of Mammalian Bypass protein
Beef	Male	0 to 7	0
		8	200
		9	220
		10	240
		11	260
		12 to 14	280
		≥ 15	0
	Female	0	0
		8	200
		9	220
		10	240
		11	260
		12 to 14	280
		≥ 15	0
Reproductive Beef	Male	0 to 6	0
		7 to 12	100
		13	150
		≥ 14	0
	Female	0 to 6	0
		7 to 12	100
		13	150
		≥ 14	0
Dairy	Male	0 to 6	0
		7 to 12	100
		13	150
		≥ 14	0
	Female	0	50
		1 to 2	100
		3	120
		4	140
		5	160
		6	180
		7	200
		8	210
		9	220
		10	230
		11	240
		12	250

Cattle Type	Gender	Age in Months	Relative Consumption of Mammalian Bypass protein
		13 to 22	0
		23 to 24	200
		25	350
		26 to 27	450
		27	450
		28	400
		29	350
		30 to 32	200
		33	100
		34 to 35	0
		36	200
		37	300
		38	350
		39 to 40	450
		41	400
		42	350
		43 to 45	200
		46	100
		47 to 48	0
		49	200
		50	300
		51	350
		52 to 53	450
		54	400
		55	350
		56 to 58	200
		59	100
		60 to 61	0
		62	200
		63	300
		64	350
		65 to 66	450
		67	400
		68	350
		69 to 70	200
		72	100
		73 to 74	0
		75	200
		76	300
		77	350
		78 to 79	450
		80	400
		81	350
		82 to 84	200
		85	100
		86 to 87	0

Cattle Type	Gender	Age in Months	Relative Consumption of Mammalian Bypass protein
		88	200
		89	300
		90	350
		91 to 92	450
		93	400
		94	350
		95 to 97	200
		98	100
		99 to 100	0
		101	200
		102	300
		103	350
		104 to 105	450
		106	400
		107	350
		108 to 110	200
		111	100
		112 to 113	0
		114	200
		115	300
		116	350
		117 to 118	450
		119	400
		120	350
		121 to 123	200
		124	100
		125 to 126	0
		127	200
		128	300
		129	350
		130 to 131	450
		132	400
		133	350
		134 to 136	200
		137	100
		138 to 139	0
		140	200
		141	300
		142	350
		143 to 144	450
		145	400
		146	350
		147 to 149	200
		150	100
		151 to 152	0
		153	200

Cattle Type	Gender	Age in Months	Relative Consumption of Mammalian Bypass protein
		154	300
		155	350
		156 to 157	450
		158	400
		159	350
		160 to 162	200
		163	100
		164 to 165	0
		166	200
		167	300
		168	350
		169 to 170	450
		171	400
		172	350
		173 to 175	200
		176	100
		177 to 178	0
		179	200
		180	300
		181	350
		182 to 183	450
		184	400
		185	350
		186 to 188	200
		189	100
		190 to 191	0
		192	200
		193	300
		194	350
		195 to 196	450
		197	400
		198	350
		199 to 201	200
		202	100
		203 to 204	0
		205	200
		206	300
		207	350
		208 to 209	450
		210	400
		211	350
		212 to 214	200
		215	100
		216 to 217	0
		218	200
		219	300

Cattle Type	Gender	Age in Months	Relative Consumption of Mammalian Bypass protein
		220	350
		221 to 222	450
		223	400
		224	350
		225 to 227	200
		228	100
		≥ 229	0

3.13.4 susceptibility

See susceptibility for the bloodInfector (Section 3.3.4).

3.14 randomInfector

See corresponding entries for the protein infector (Section 3.13).

3.15 rateSlaughter

3.15.1 rateSlaughter

Cattle Type	Gender	Age in Months	Proportion of Animals Slaughtered Monthly
Beef	Male	0 to 10	0
		11 to 12	0.05
		13 to 17	0.1
		18 to 21	0.2
		22 to 23	0.5
		24	1
	Female	0 to 10	0
		11 to 12	0.05
		13 to 17	0.1
		18 to 21	0.2
		22 to 23	0.5
		24	1
Beef Reproductive	Male	0 to 12	0
		13 to 23	0.0125
		24 to 32	0.0208
		33 to 41	0.0216

Cattle Type	Gender	Age in Months	Proportion of Animals Slaughtered Monthly
		42 to 53	0.0225
		54 to 64	0.0233
		65 to 76	0.0241
		77 to 238	0.025
		239	0.9975
		240	1
	Female	0 to 23	0
		24 to 47	0.004167
		48 to 156	0.008333
		157	0.999
		158	1
Dairy	Male	0	0
		1	0.6
		2	0.3
		3	0.2
		4 to 12	0.15
		13 to 23	0.0125
		24 to 32	0.0208
		33 to 41	0.0216
		42 to 53	0.0225
		54 to 64	0.0233
		65 to 76	0.0241
		77 to 88	0.025
		89 to 158	0.0258
		159	0.9975
		160	1
	Female	0 to 15	0.000833
		16 to 21	0.004167
		22 to 33	0.015
		34 to 48	0.016667
		49 to 60	0.018333
		61 to 72	0.0225
		73 to 84	0.026667
		85 to 146	0.041667
		147	0.9969
		148	1

3.16 renderer

3.16.1 renderFactor

Rendering Reduction Factor	Proportion of Rendering Facilities

1259	0.05
100	0.45
10	0.45
1	0.05

3.16.2 probContamination

The probability that Prohibited MBM could contaminate Non Prohibited MBM in a mixed rendering facility is 0.14.

3.16.3 probType

Type of MBM Producer	Probability that Animal will be Sent to MBM Producer of This Type
Prohibited MBM Producer	0.949999
Non Prohibited MBM Producer	0.000001
Mixed MBM Producer	0.05

3.16.4 probMislabel

Type of MBM Producer	Probability that Prohibited Material will be Mislabeled
Prohibited MBM Producer	0.05
Non Prohibited MBM Producer	1
Mixed MBM Producer	0.05

3.16.5 fracContaminate

The fraction of Prohibited MBM that will contaminate non prohibited MBM in a mixed rendering facility when contamination occurs: 0.001

3.17 sickBovine

3.17.1 clinicalDate

Duration of Incubation Period (Months)	Probability
0 to 11	$\leq 1 \times 10^{-6}$
12	1×10^{-6}
13	2.8×10^{-6}

Duration of Incubation Period (Months)	**Probability**
14	7.0×10^{-6}
15	1.6×10^{-5}
16	3.5×10^{-5}
17	7.1×10^{-5}
18	0.000136
19	0.000243
20	0.000412
21	0.000668
22	0.001035
23	0.001539
24	0.002203
25	0.003048
26	0.004085
27	0.005316
28	0.006733
29	0.00832
30	0.010048
31	0.011883
32	0.013785
33	0.015709
34	0.017611
35	0.019448
36	0.021181
37	0.022777
38	0.024208
39	0.025453
40	0.026497
41	0.027334
42	0.027961
43	0.028382
44	0.028606
45	0.028643
46	0.028508
47	0.028218
48	0.027788
49	0.027237
50	0.026582
51	0.02584
52	0.025027
53	0.024158
54	0.023248
55	0.022309
56	0.021351
57	0.020386
58	0.019421
59	0.018464
60	0.017521

Appendix 1

Duration of Incubation Period (Months)	**Probability**
61	0.016598
62	0.015699
63	0.014826
64	0.013984
65	0.013173
66	0.012395
67	0.01165
68	0.01094
69	0.010264
70	0.009622
71	0.009013
72	0.008437
73	0.007893
74	0.00738
75	0.006896
76	0.006441
77	0.006013
78	0.005611
79	0.005234
80	0.004881
81	0.00455
82	0.00424
83	0.003951
84	0.00368
85	0.003426
86	0.00319
87	0.002969
88	0.002763
89	0.002571
90	0.002392
91	0.002225
92	0.00207
93	0.001925
94	0.00179
95	0.001664
96	0.001547
97	0.001438
98	0.001337
99	0.001243
100	0.001155
101	0.001073
102	0.000998
103	0.000927
104	0.000861
105	0.0008
106	0.000744
107	0.000691

Duration of Incubation Period (Months)	Probability
108	0.000642
109	0.000596
110	0.000554
111	0.000515
112	0.000478
113	0.000444
114	0.000413
115	0.000383
116	0.000356
117	0.000331
118	0.000307
119	0.000285
120	0.000265
121	0.000246
122	0.000229
123	0.000212
124	0.000197
125	0.000183
126	0.00017
127	0.000158
128	0.000147
129	0.000136
≥ 130	0.000127

3.17.2 clinicalDuration

Duration Between Manifestation of Clinical Signs and Death (Months)	Probability
2	0.2
3	0.2
4	0.2
5	0.2
6	0.2

3.17.3 maternalContagiousPoint

The fraction of the incubation period that must pass before a cow can transmit BSE directly to her calf is 0.833.

3.18 splitter

3.18.1 fracAerosol

Fraction of spinal cord that contaminates muscle during the splitting process: 0.0000108.

3.18.2 probMS_AMR_SCRemove

Mis-split/AMR/Spinal Cord Removal Outcome[a]	Probability for Age: 0-12 Months	13-23 Months	≥ 24 Months
No-No-No	0.475	0.16625	0.184
No-No-Yes	0.475	0.16625	0.184
No-Yes-No	0	0.01235	0.01104
No-Yes-Yes	0	0.60515	0.54096
Yes-No-No	0.025	0.00875	0.016
Yes-No-Yes	0.025	0.00875	0.016
Yes-Yes-No	0	0.00065	0.00096
Yes-Yes-Yes	0	0.03185	0.04704

Notes:

a. The first No/Yes indicates whether there is a mis-split. The second No/Yes indicates whether the facility uses AMR. The third No/Yes indicates whether the facility removes spinal cords.

3.18.3 fracSCInMuscle, fracSCInAMRMeat, fracSCInBone

fracSCInMuscle

Mis-split/AMR/Spinal Cord Removal Outcome[a]	Proportion of Spinal Cord Deposited in Muscle Meat for Age: 0-12 Months	13-23 Months	≥ 24 Months
No-No-No	0	0.001	0.001
No-No-Yes	0	0	0
No-Yes-No	0	0.001	0.001
No-Yes-Yes	0	0	0
Yes-No-No	0	0.001	0.001
Yes-No-Yes	0	0	0
Yes-Yes-No	0	0.001	0.001
Yes-Yes-Yes	0	0	0

Notes:

a. The first No/Yes indicates whether there is a mis-split. The second No/Yes indicates whether the facility uses AMR. The third No/Yes indicates whether the facility removes spinal cords.

fracSCInAMRMeat

Mis-split/AMR/Spinal Cord Removal Outcome[a]	Proportion of Spinal Cord Deposited in AMR Meat for Age: 0-12 Months	13-23 Months	≥ 24 Months
No-No-No	0	0	0.001
No-No-Yes	0	0	0
No-Yes-No	0	0.35	0.5
No-Yes-Yes	0	0	0
Yes-No-No	0	0	0
Yes-No-Yes	0	0	0
Yes-Yes-No	0	0.344	0.461
Yes-Yes-Yes	0	0.006	0.009

Notes:

a. *The first No/Yes indicates whether there is a mis-split. The second No/Yes indicates whether the facility uses AMR. The third No/Yes indicates whether the facility removes spinal cords.*

fracSCInBone

Mis-split/AMR/Spinal Cord Removal Outcome[a]	Proportion of Spinal Cord Deposited in Cuts of Meat with Bone for Age: 0-12 Months	13-23 Months	≥ 24 Months
No-No-No	0	0.3	0
No-No-Yes	0	0	0
No-Yes-No	0	0.3	0
No-Yes-Yes	0	0	0
Yes-No-No	0	0.3	0
Yes-No-Yes	0	0	0
Yes-Yes-No	0	0.3	0
Yes-Yes-Yes	0	0	0

Notes:

a. *The first No/Yes indicates whether there is a mis-split. The second No/Yes indicates whether the facility uses AMR. The third No/Yes indicates whether the facility removes spinal cords.*

3.18.4 fracDRGInMuscle, fracDRGInAMRMeat, fracDRGInBone

FracDRGInMuscle

Mis-split/AMR/Spinal Cord Removal Outcome[a]	Proportion of DRG Deposited in Muscle Meat for Age: 0-12 Months	13-23 Months	≥ 24 Months
No-No-No	0	0.001	0
No-No-Yes	0	0	0
No-Yes-No	0	0.001	0
No-Yes-Yes	0	0	0
Yes-No-No	0	0.001	0
Yes-No-Yes	0	0	0
Yes-Yes-No	0	0.001	0
Yes-Yes-Yes	0	0	0

Notes:

a. *The first No/Yes indicates whether there is a mis-split. The second No/Yes indicates whether the facility uses AMR. The third No/Yes indicates whether the facility removes spinal cords.*

FracDRGInAMRMeat

Mis-split/AMR/Spinal Cord Removal Outcome[a]	Proportion of DRG Deposited in AMR Meat for Age: 0-12 Months	13-23 Months	≥ 24 Months
No-No-No	0	0	0
No-No-Yes	0	0	0
No-Yes-No	0	0.35	0.5
No-Yes-Yes	0	0.35	0.5
Yes-No-No	0	0	0
Yes-No-Yes	0	0	0
Yes-Yes-No	0	0.35	0.5
Yes-Yes-Yes	0	0.35	0.5

Notes:

a. *The first No/Yes indicates whether there is a mis-split. The second No/Yes indicates whether the facility uses AMR. The third No/Yes indicates whether the facility removes spinal cords.*

FracDRGInBone

Mis-split/AMR/Spinal Cord Removal Outcome[a]	Proportion of DRG Deposited in Cuts of Meat with Bone for Age: 0-12 Months	13-23 Months	≥ 24 Months
No-No-No	0	0.3	0
No-No-Yes	0	0.3	0
No-Yes-No	0	0.3	0
No-Yes-Yes	0	0.3	0
Yes-No-No	0	0.3	0
Yes-No-Yes	0	0.3	0
Yes-Yes-No	0	0.3	0
Yes-Yes-Yes	0	0.3	0

Notes:

a. The first No/Yes indicates whether there is a mis-split. The second No/Yes indicates whether the facility uses AMR. The third No/Yes indicates whether the facility removes spinal cords.

3.19 Stunner

3.19.1 probDrip

The probability that brain tissue will drip from the hole created by the stunner, contaminating blood drained from the carcass is 0.0 for stunners not using air injection and 0.30 for stunners that do use air injection.

3.19.2 fracDrip

The fraction of brain infectivity that contaminates blood if tissue drips from the stunner hole is 0.04.

3.19.3 probType

No stunners use air injection.

3.19.4 probOK

Stunners that do not use air injection operate properly with 100% probability. Air injected pneumatic stunners operate properly with 98.61% probability.

3.19.5 emboli

Stunner Uses Air Injection	Stunner Operates Properly	Tissue in Which Emboli are Deposited	Probability that Emboli are Deposited in Tissue	Fraction of Brain Tissue Deposited in Organ	
				Lower Bound	Upper Bound
No	Yes	Brain	0	0	0
		Spinal cord	0	0	0
		Dorsal Root Ganglia	0	0	0
		Blood	0.5	0.000133	0.00267
		Ileum	0	0	0
		Heart	0	0	0
		Lung	0	0	0
		Liver	0	0	0
		Kidney	0	0	0
		Eyes	0	0	0
		Muscle	0	0	0
		AMR Meat	0	0	0
		Bone	0	0	0
		Trigeminal Ganlia	0	0	0
	No	Brain	0	0	0
		Spinal cord	0	0	0
		Dorsal Root Ganglia	0	0	0
		Blood	0.5	0.000133	0.00267
		Ileum	0	0	0
		Heart	0	0	0
		Lung	0	0	0
		Liver	0	0	0
		Kidney	0	0	0
		Eyes	0	0	0
		Muscle	0	0	0
		AMR Meat	0	0	0
		Bone	0	0	0
		Trigeminal Ganlia	0	0	0
Yes	Yes	Brain	0	0	0
		Spinal cord	0	0	0
		Dorsal Root Ganglia	0	0	0
		Blood	0.31185	0.00267	0.0333
		Ileum	0	0	
		Heart	0.16285	0.000267	0.0107
		Lung	0.03255	0.000267	0.0107
		Liver	0.0065	0.000267	0.004
		Kidney	0	0	0
		Eyes	0	0	0
		Muscle	0	0	0
		AMR Meat	0	0	0

Stunner Uses Air Injection	Stunner Operates Properly	Tissue in Which Emboli are Deposited	Probability that Emboli are Deposited in Tissue	Fraction of Brain Tissue Deposited in Organ: Lower Bound	Fraction of Brain Tissue Deposited in Organ: Upper Bound
		Bone	0	0	0
		Trigeminal Ganlia	0	0	0
	No	Brain	0	0	0
		Spinal cord	0	0	0
		Dorsal Root Ganglia	0	0	0
		Blood	0.43335	0.0267	0.107
		Ileum	0	0	0
		Heart	0.3	0.00267	0.107
		Lung	0.3	0.00267	0.107
		Liver	0.06	0.00267	0.04
		Kidney	0	0	0
		Eyes	0	0	0
		Muscle	0	0	0
		AMR Meat	0	0	0
		Bone	0	0	0
		Trigeminal Ganlia	0	0	0

3.20 Other Parameters

3.20.1 farmDeathDisp

The probability that cattle dying on farm is sent to rendering: 0.85